Sandy Hook
Sand Slurry Pipeline Project

Biological Assessment

Sandy Hook Unit
Gateway National Recreation Area
National Park Service
U.S. Department of the Interior
Sandy Hook, New Jersey

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EXECUTIVE SUMMARY

Sandy Hook, the northernmost 7 miles of barrier beach along New Jersey's coast, has a long history of persistent shoreline erosion and change. A four-mile seawall constructed in the early 1900's immediately adjacent to the National Seashore has effectively prevented the natural transport of sediment into Sandy Hook. This long-standing artificial structure has resulted in steepened nearshore slopes and significant shoreline retreat at its northern terminal—the southern beaches (Critical Zone) of Sandy Hook.

Since its inception as a National Recreation Area (NRA) Unit in 1976, the National Park Service (NPS) has attempted to maintain Sandy Hook's shoreline in order to provide continued recreational opportunities and protect its significant natural and cultural resources. Accelerated erosion with subsequent shoreline retreat due to the adjacent man-made structures threatens Sandy Hook's resources as well as the NPS' present level of use and operations. Continued erosion will likely result in a breach to the peninsula, damage NPS physical and historical facilities and beaches, and severely restrict access by the public and tenants.

Since 1976, the NPS has been pursuing and evaluating practical alternatives to address this problem and provide for continued operations and public access to NPS resources, while minimizing adverse impacts to its exemplary cultural and natural resources. Two alternatives have been evaluated in this biological assessment. They are (A) No Action, and (B) Sand Slurry Pipeline. Two options for sand removal are included in the Sand Slurry Pipeline alternative; pipeline with crane and clamshell bucket for sand removal, and pipeline with eductor sand removal. Each of these alternatives may have an impact on the shoreline as well as the protected species that inhabit the beach.

The National Park Service has prepared this Biological Assessment Pursuant to Section 7 of the Endangered Species Act (ESA) in order to evaluate the potential effects of each of the 2 alternatives on the three federally threatened or endangered species that occur within the project area. This document provides the most current data available on the status of the piping plover (*Charadrius melodus*), seabeach amaranth (*Amaranthus pumilis*), and the northeastern beach tiger beetle (*Cicindella dorsalis dorsalis*) and assesses potential impacts to these protected species under each alternative. Consideration is also given to the suite of federal and state protected sea turtles and marine mammals that inhabit the coastal waters adjacent to the project as well as two species listed by the state of New Jersey, seabeach knotweed (*Polygonum glaucum*) and the least tern (*Sterna antillarum*) that occur within the project area.

PROJECT AREA

Sandy Hook is an 1825-acre (730-hectare) accreting, recurved barrier spit extending northwest from central New Jersey into lower New York Bay. There are approximately 7 miles (11.2 km) of ocean shoreline, varying in width from 0.06 miles to1.02 miles (0.1 to 1.7 km). The Atlantic Ocean is to the east and Sandy Hook Bay is to the west. Sandy

Hook lies at the northern end of the barrier island system of New Jersey. It remains one of New Jersey's most heavily-used beaches and best examples of a "natural" beach community and shoreline (Figure 1). It is culturally rich as well and contains the oldest operating Lighthouse in the U.S. as well as Fort Hancock, which guarded the harbor for nearly a century.

Sandy Hook is administered by the NPS as a unit of Gateway NRA. Gateway NRA preserves unique biological and cultural sites in and around New York Harbor. Over two million people visit Sandy Hook annually, with about 46,000 visitors on summer weekends. Most use the ocean beaches for swimming and surfing, sunbathing, picnicking, beach walking, kite flying, and fishing. NPS management for human disturbance established six protected areas that contain all of the nesting piping plovers (as well as other rare beach flora and fauna). These areas comprise almost 50% of the Sandy Hook shoreline and about 90% of the wide, northern beaches.

Sandy Hook Shoreline

Background

Sandy Hook is part of the Atlantic Coast barrier island system. It ranges in width from several hundred feet at the southern end to approximately a mile in the north. The Sandy Hook seashore is a dynamic environment, directly influenced by the natural processes that continually alter its configuration and natural systems.

Like most barrier island and spit systems, Sandy Hook has experienced dynamic geomorphologic changes (Figure 2). Within the last two centuries alone, it has been an island, it has been connected to the mainland at two different sites; and it has had as many as four inlets joining the ocean and the Navesink-Shrewsbury River system (Gorman 1988, Gares 1981). Beginning in 1900, however, significant effort and commitment was made to stabilize the New Jersey coast. These shoreline stabilization efforts have significantly affected the geomorphologic dynamics of Sandy Hook, creating an unnatural near-shore sand transport system. These established and permanent man-made structures along adjoining townships pose a challenge to NPS management and operations on the NRA.

Figure 1. Sandy Hook Project Area, Gateway NRA

View GRAPHIC 1 File

Figure 2. Sandy Hook Historical Shoreline

View GRAPHIC 9 File

Shoreline stabilization efforts immediately to the south of Sandy Hook have significantly altered the NPS shoreline since 1900 and created a sand deficit along its southern "Critical Zone" (Allen 1981, Phillips *et al.* 1984, Slezak *et al.* 1984). The Critical Zone, located one mile north of the Park entrance and four miles south of Fort Hancock, is the narrowest section along the Sandy Hook peninsula and is an area of instability due to ongoing, severe beach erosion. Although major storms are responsible for some of the shoreline erosion that occurs, they are not the primary source of the problem. Jetties and groins, built over the decades in Monmouth Beach and Sea Bright, and the sea wall near the southern boundary of the Park, have prevented sand from reaching Sandy Hook's southern beaches (Psuty and Namikas 1991). These beach protection structures, designed to prevent erosion, have actually interfered with the northern littoral drift of sand along the New Jersey shoreline. Although some sand is still deposited at the Critical Zone, the amount is insufficient to counter losses due to erosion. As a result, the sand deficit at the southern end of Sandy Hook continues to grow.

In contrast to the severe beach erosion experienced at the Park's southern beaches, beaches at the northern end of the hook are experiencing active sand accretion. Gunnison, North, and Coast Guard Beaches have all enlarged due to accretion. As Sandy Hook continues to expand to the north, periodic dredging is required to prevent the continued drift of the Hook into shipping channels of lower New York Bay.

Beach conditions are changing along Sandy Hook, as the southern beaches are now widening, but still in severe sand deficit. The Critical Zone remains highly erosive in spite of continuing stabilization efforts. The steep beach face slope is indicative of this condition. Northern beaches, however, are widening considerably as they accrete from the northerly transport of sand. As a result, Gunnison, North and Coast Guard Beaches have become progressively more vegetated each year. Elevation has not changed significantly, however, as the ephemeral pools continue to be maintained by tidal action. Coast Guard Beach has grown considerably in size, but its western edge is narrowing from bayside conditions

Sediment Budgets Update

Monitoring data collected since the Park's establishment has documented that the sand deficit at the Critical Zone is closely tied to the net accumulation of sand at Gunnison and North Beaches. The sand deficit at the Critical Zone can be viewed as a sediment budget problem, in which more material is being transported from and around the site than is being introduced. A key requirement for managing the resources of the area under such a condition involves establishing the modern-day sand deficit and rates of transport at the site. Although several studies of the magnitudes of longshore transport and erosion at Sandy Hook have been published, these are generally regional in scope, and have limited applicability at the Critical Zone.

Data collected since the 1970s have documented sand transport rates and deficits around Sandy Hook and an increasing rate of erosion in the Critical Zone due to human interference with the natural sediment supply to the spit. This rate, relative to the period of 1953-78, has been reasonably stable at a loss of 220,000 cy/yr from 1984-97. The data also indicate seasonal variations in the transport of sediment and beach responses as well as lag-time effects after major nourishment projects along the shore.

Since the spring of 1997, however, the erosion rate has decreased due to an increase in the amount of sand coming northward to Sandy Hook from erosion of beach fill in the communities of Sea Bright and Monmouth Beach, New Jersey. Monitoring efforts since 1997 indicate that there are, on average, about 200,000 to 250,000 cy of sand moving through the Critical Zone (erosion) and Gunnison Beach (potential accretion) in the form of migrating shoals (Psuty 2001-2003). The total input of sand to the Critical Zone during 1997 was slightly greater than the volumetric losses. This includes about 60,000 cy of sand trucked from Gunnison Beach at the northern end of Sandy Hook and molded into a sand berm during February and March of that year. Therefore, the natural sediment budget had a deficit of 40-50,000 cy.

Between December 1997 and March 1998, the National Park Service placed 287,500 cy of sand at the Critical Zone and at Beach Areas D and E. Subsequent analysis on the performance of this beach fill and conditions in the Critical Zone revealed the annual loss of sand has been approximately 55,000 cy/yr. Most recently, in November 2002 an additional 253,000 cy of sand was placed to insure adequate sand in the Critical Zone/Gunnison Beach system for a sand recycling program to work most effectively.

Although there is now a substantial amount of sediment moving around the end of the seawall at the southern end of the Park, it is insufficient to balance the losses. Furthermore, the US Army Corps of Engineers (ACOE) adjacent beach renourishment project is expected to continue for 50 years, but sources of sand from the south may become depleted in the future. Renourishment is scheduled for adjacent Sea Bright beaches on a 5-7 year cycle. Existing groins in the Park, now covered by sand and rendered nonfunctional, might then play a role in blocking sand transport if they become exposed. The overall Park deficit is expected to return to its more recent typical value of 220,000 cy/yr, deficit in the Critical Zone (Psuty 2001-2003, Psuty and Allen unpubl. data).

Accretion Rates at Gunnison Beach.

Prior to 1983, the shoreline in the Gunnison Beach area was less than 200 ft seaward of the Battery location. The shoreline oscillated on a three to four-year cycle since at least the 1950's, and the timber groin just east of the Battery was occasionally exposed. A semi-annual cycle was also present, wherein the beach was narrower in the winter storm season and wider in the summer, although this seasonal change was less than the longer scale oscillation. Following sand emplacement in 1982-84, Gunnison Beach has been a site of nearly continuous accretion. Analysis of data collected indicates average accretion between 1984 and 1994 has been approximately 210,000 cy/yr (160,600 cubic meters/yr). Accretion levels were higher in the several years following nourishment in 1983, 1984, and 1989 (Psuty and Allen unpubl. data).

In the years following NPS nourishment projects, the rate of accretion at Gunnison Beach increased to 290,000 cy/yr (221,734 cubic meters/yr). This indicated a higher rate of mobilization and transfer while the nourished area at South Beach was undergoing morphological adjustment to the sediment transport process. The comparability of the volumetric changes in the Critical Zone with those at Gunnison Beach indicates that the Critical Zone losses correlate with accretion at Gunnison Beach over time.

The compatibility of the volumetric changes in the Critical Zone with those at Gunnison Beach over time indicates that losses at the Critical Zone are correlated with gains at Gunnison Beach with a lag time of one to two years (Psuty and Namikas 1991, Psuty 1997, 2001-2003). In addition, approximately 300,000 cy of sand has passed through Gunnison Beach annually to accumulate either at North Beach, at the end of the Sandy Hook spit, or in the navigation channel just beyond the end of the Hook. Thus, on the basis of the quantity of sediment available in transit through the system, there is an ample supply to permit removal of 100,000 cy of sand per year and transport it back to the Critical Zone to balance the erosion losses there (Psuty and Allen, unpubl.data; Psuty 2001-2003).

At Gunnison Beach, sand moves through the area in the form of broad migratory shoals which extend from the beach face out to the nearshore. These shoals begin at the change in shoreline orientation about 500 y to the south of the Gunnison Recreational Beach. Because of the change in orientation and the availability of sand in transport, there is an accumulation that tends to extend the beach northerly at that location instead of being redirected to the north- northwest. Incident waves work on these shoals and on the small downdrift spit extension that begins in a northerly direction and changes to north-northwest. The mass of sand that forms these small shoals then begins to migrate along the Gunnison shoreline, with the spit tending to migrate landward as it shifts northerly. Eventually, the spit welds onto the beach and alongshore to broaden the intertidal zone. At times, there may be no changes to the net beach conditions once the shoals have passed, but during other times, the beach may accumulate some of this sediment and widen as well as heighten. Historically, the beach has been widening with the passage of these spit extensions. In the past few years, some of these shoals have been observed to continue to migrate through the Gunnison Beach area and into the next beach facet to the north along the navigation channel (North and Coastguard Beach). Large spit shoals have been recorded migrating through that portion of the beach as well. Psuty (2001-2003) has recorded up to four spit/shoals migrating through at one time. Recent analyses of these shoals and beach profiles in October- December 2001 indicate that the shoal off of the Gunnison bathing beach contains 29,000- 44,000 cy alone.

Natural Resources of Concern

Dune Habitat

Floral communities are important to the formation, persistence, and health of beach and dune environments. For instance, primary dunes are created by the slow accumulation of eolian sand at the base of beach vegetation, particularly American beachgrass (*Ammophila breviligulata*), and beach debris. The root and rhizome systems of beach flora together with mychorizal fungi then serve to bind together fine sand and soil particles, thereby minimizing erosion and stabilizing the dune. Remaining plants and their rhizomes still attached to a dune may also aid in the repair/re-accretion of sand on that damaged dune. In addition, beach and dune vegetation provides critical food, nesting sites, and protective cover for various types of wildlife.

Natural dunes or remnants are present within the study area, especially along the northern accreting section of Sandy Hook. The presence and sizes of dunes vary throughout the project area. In typical natural beach profiles along New Jersey's Coast, more than one dune may exist. The primary species of dune flora are adapted to the harsh conditions present such as low fertility, salinity, heat, and high energy from the ocean and wind. The dominant plant on these dunes is American beachgrass, which is tolerant to salt spray, shifting sands and temperature extremes. Beachgrass is important in the development of dune stability, which allows for further dune colonization with other pioneer species like seaside goldenrod (*Solidago sempervirens*), sea rocket (*Cakile edentula*) and beach clotbur (*Xanthium echinatum*).

The secondary dunes lie landward of the primary dunes, and tend to be more stable resulting from the protection provided by the primary dunes. The increased stability also allows an increase in plant species diversity. Some of the plant species in this zone include: beach heather (*Hudsonia tomentosa*), coastal panic grass (*Panicum amarum*), saltmeadow hay (*Spartina patens*), broom sedge (*Andropogon virginicus*), beach plum (*Prunus maritima*), seabeach evening primrose (*Oenothera humifusa*), sand spur (*Cenchrus tribuloides*), seaside spurge (*Ephorbia polygonifolia*), joint-weed (*Polygonella articulata*), slender-leaved goldenrod (*Solidago tenuifolia*), and prickly pear (*Opuntia humifusa*).

The area behind these dunes transitions into a zone of shrubby vegetation. These zones are typically located on the barrier flats of the barrier beaches. This zone is called the scrub-thicket zone where sand movement is more diminished. Much of the flora consists of dwarf trees and shrubs which include: wax-myrtle (*Myrica cerifera*), bayberry (*M. pensylvanica*), dwarf sumac (*Rhus copallina*), poison ivy (*Toxicodendron radicans*), black cherry (*Prunus serotina*), American holly (*Ilex opaca*), greenbrier (*Smilax spp*.), groundsel bush (*Baccharis halimifolia*), pitch pine (*Pinus rigida*), Virginia creeper (*Parthenocissus quinquefolia*), beach plum (*Prunus maritima*) and others.

Sandy Hook's holly forest, and the larger deciduous forest to the north which includes nearly 300 acres of American holly, are unique locally and rare along the northeastern Atlantic coast. The forest represents the greatest density of maritime holly in the region and is under consideration as a National Natural Landmark (NPS 1990, 2001).

Upper Beach Habitat

An upper beach or supralittoral zone is present within the study area; however, it is subject to disturbance from human activity along much of the immediate project area, although generally protected along much of the remainder of Sandy Hook. The upper beach zone is only covered with water during periods of extremely high tides and large storm waves and is characterized by sparse vegetation and low faunal diversity. Although more common on southern beaches, the ghost crab (*Ocypode quadrata*), is active in this zone. In addition to ghost crabs, species of sand fleas or amphipods

(Talitridae), predatory and scavenger beetles and other transient animals may be found in this zone. Several species of tiger beetles (Cicindella) occur here as well as an assortment of wrack insects.

Piping Plover

Piping plovers are small, sand-colored shorebirds, approximately 17 centimeters (cm) (7 inches) long with a wingspread of about 38 cm (15 inches) (Palmer 1967). On January 10, 1986, the piping plover was listed as endangered and threatened pursuant to the ESA. Protection of the species under the ESA reflects the species precarious status range-wide. Three distinct populations were identified and listed separately: Atlantic Coast (threatened), Great Lakes (endangered), and Northern Great Plains (threatened). The Atlantic Coast population breeds on sandy, coastal beaches from Newfoundland to North Carolina, and winters along the Atlantic coast from North Carolina south, along the Gulf coast to Texas, and in the Caribbean (US Fish and Wildlife Service (FWS) 1985). On July 10, 2001, the Service designated critical habitat for wintering piping plovers, including areas used by wintering plovers from the Atlantic Coast population. Critical habitat was also designated in the Great Lakes breeding area on May 7, 2001, and proposed for the Northern Great Plains breeding area on June 12, 2001 (FWS 2001). No critical habitat has been designated or proposed in the Atlantic coast breeding area.

The recovery plan for the Atlantic coast population of the piping plover (FWS 1996b) delineates four recovery units or geographic subpopulations within the population: Atlantic Canada, New England, New York-New Jersey, and Southern (Delaware, Maryland, Virginia, and North Carolina). Recovery criteria established within the recovery plan defined population and productivity goals for each recovery unit, as well as for the population as a whole. Attainment of these goals for each recovery unit is an integral part of a piping plover recovery strategy that seeks to reduce the probability of extinction for the entire population by: (1) contributing to the population total, (2) reducing vulnerability to environmental variation (including catastrophes, such as hurricanes, oil spills, or disease), (3) increasing likelihood of genetic interchange among subpopulations, and (4) promoting re-colonization of any sites that experience declines or local extirpations due to low productivity or temporary habitat succession. The plan further states: "A premise of this plan is that the overall security of the Atlantic Coast piping plover population is profoundly dependent upon attainment and maintenance of the minimum population levels for the four recovery units. Any appreciable reduction in the likelihood of survival of a recovery unit will also reduce the probability of persistence of the entire population." In accordance with the Endangered Species Consultation Handbook (FWS and National Marine Fisheries Service (NMFS) 1998), since recovery units have been established in an approved recovery plan, this Biological Assessment considers the effects of the proposed project on piping plovers in the New York–New Jersey Recovery Unit, as well as the Atlantic coast population as a whole.

Piping plovers return to their Atlantic Coast nesting beaches in mid-March (Coutu *et al.* 1990, Cross 1990, Goldin 1990, MacIvor 1990, Hake 1993). Males establish and defend territories and court females (Cairns, 1982). Piping plovers are monogamous, but usually shift mates between years (Wilcox 1959, Haig and Oring 1988, MacIvor 1990), and less frequently between nesting attempts in a given year (Haig and Oring 1988, MacIvor 1990, Strauss 1990). Plovers are known to begin breeding as early as one year of age (MacIvor 1990, Haig 1992); however, the percentage of birds that breed in their first adult year is unknown.

Piping plover nests can be found above the high tide line on coastal beaches, on sand flats at the ends of sand spits and barrier islands, on gently sloping foredunes, in blowout areas behind primary dunes, and in washover areas cut into or between dunes. The birds may also nest on areas where suitable dredge material has been deposited. Nest sites are shallow, scraped depressions in substrates ranging from fine-grained sand to mixtures of sand and pebbles, shells or cobble (Bent 1929, Burger 1987, Cairns 1982, Patterson 1988, Flemming *et al*. 1990, MacIvor 1990, Strauss 1990). Nests are usually found in areas with little or no vegetation although, on occasion, piping plovers will nest under stands of American beachgrass or other vegetation (Patterson 1988, Flemming *et al.* 1990, MacIvor 1990). Plover nests may be very difficult to detect, especially during the 6- to 7-day egg-laying phase when the birds generally do not incubate (Goldin 1994).

Eggs may be present on the beach from early April through late July. Clutch size for an initial nest attempt is usually four eggs, one laid every other day. Eggs are pyriform in shape, and variable buff to greenish brown in color, marked with black or brown spots. The incubation period usually lasts 27-28 days. Full-time incubation usually begins with the completion of the clutch and is shared equally by both sexes (Wilcox 1959, Cairns 1977, MacIvor 1990). Eggs in a clutch usually hatch within 4 to 8 hours of each other.

Piping plovers generally fledge only a single brood per season, but may renest several times if previous nests are lost. Chicks are precocial (Wilcox 1959, Cairns 1982). They may move hundreds of meters from the nest site during their first week of life (FWS 1994a), and chicks may increase their foraging range up to 1,000 m before they fledge (are able to fly) (Loegering 1992). Chicks remain together with one or both parents until they fledge at 25 to 35 days of age. Depending on date of hatching, flightless chicks may be present from mid-May until late August, although most fledge by the end of July (Patterson 1988, Goldin 1990, MacIvor 1990, Howard *et al.* 1993).

Cryptic coloration is a primary defense mechanism for this species; nests, adults, and chicks all blend in with their typical beach surroundings. Chicks sometimes respond to vehicles and/or pedestrians by crouching and remaining motionless (Cairns 1977, Tull 1984, Goldin 1993, Hoopes 1993). Adult piping plovers also respond to intruders (avian and mammalian) in their territories by displaying a variety of distraction behaviors, including squatting, false brooding, running, and injury feigning. Distraction displays may occur at any time during the breeding season, but are most frequent and intense around the time of hatching (Cairns 1977).

Plovers feed on invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks (Bent 1929, Cairns 1977, Nicholls 1989). Important feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sand flats, wrack lines, sparse vegetation, and shorelines of coastal ponds, lagoons or salt marshes (Gibbs 1986, Coutu *et al.* 1990, Hoopes *et al.* 1992, Loegering 1992, Goldin 1993, Ellias-Gerken 1994). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986, Coutu, *et al.* 1990, McConnaughey *et al*. 1990, Loegering

1992, Goldin 1993, Hoopes 1993, Ellias-Gerken 1994), and by stage in the breeding cycle (Cross 1990). Adults and chicks on a given site may use different feeding habitats in varying proportion (Goldin 1990). Feeding activities of chicks are particularly important to their survival. Most time budget studies reveal that chicks spend a high proportion of their time feeding.

Cairns (1977) found that piping plover chicks typically tripled their weight during the first two weeks post-hatching; chicks that failed to achieve at least 60 percent of this weight gain by the twelfth day were unlikely to survive. During courtship, nesting, and brood rearing, feeding territories are generally contiguous to nesting territories (Cairns 1977), although instances where brood-rearing areas are widely separated from nesting territories are not uncommon. Feeding activities of both adults and chicks may occur during all hours of the day and night (Burger, 1993), and at all stages in the tidal cycle (Goldin 1993, Hoopes 1993).

Migration patterns are not well understood. Most piping plover surveys have focused on breeding or wintering sites. Northward migration occurs during late February, March, and early April; southward migration extends from late July to August and September. Both spring and fall migration routes are believed to primarily occur within a narrow zone along the Atlantic Coast (FWS 1996b, 2002 a and b).

In 2002, productivity in the NY-NJ Recovery Unit (1.49 chicks fledged per pair) exceeded long-term averages (1.14 chicks fledged per pair). Figure 3 depicts plover and other rare species locations within the project area. The total 2002 U.S. Atlantic Coast breeding pair count of 1,407 pairs is the highest since the species' 1986 listing under the ESA. Increases occurred in all three U.S. Atlantic recovery units, with the largest percentage gains occurring in the NY-NJ Recovery Unit. (2003 figures have not been compiled and confirmed as of this date). Population estimates in the NY-NJ Recovery Unit grew by fifteen percent in 2000, seven percent in 2001, and fifteen percent in 2002. Increases occurred in both states and recent gains in New Jersey appear to have recouped the major population decrease that occurred in the late 1990s.

New Jersey piping plover productivity rates have averaged higher during the years 1999-2002 than at any time since productivity monitoring began in 1987 (Jenkins and Pover 2001). A severe winter may have contributed to the formation of less than optimal breeding/nesting habitat for the plovers in 2003 resulting in a much-reduced fledging rate despite the area having the highest number of nesting pairs since 1997. Although productivity remains slightly below the modeled recovery goal for population growth (1.50 chicks/pair), populations in New Jersey have increased each year since 1999 (2003 excluded). Fledging rates have exceeded levels believed necessary for model population maintenance (1.24 chicks/pair). NJDEP suggests that improved pair-nest success has resulted primarily from reducing nest losses to predation through increased use of predator exclosures.

The combined observations of population increases and improved productivity observed in New Jersey over the past 3-4 years suggests that if productivity rates can be sustained at current levels, New Jersey may begin to contribute to achieving regional and population-wide piping plover recovery goals (Jenkins and Pover 2001, 2003).

Table 1 summarizes the breeding piping plover population status at Sandy Hook over the last 13 years (McArthur 2000-2003). Both abundance and productivity have varied significantly during this period. Sandy Hook has witnessed a highly variable hatching rate but a more consistent fledging rate. Aberrant predation and weather/flood events contributed to this highly variable hatch rate.

Figure 3. Natural Resources of Concern

View <u>GRAPHIC 3</u> File

Table 1. Piping Plover Abundance and Productivity from 1991-2003. (Source: J. McArthur, NPS)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
# of nesting pairs	20	21	25	36	43	40	42	29	27	29	31	35	38
# of eggs	83	87	100	146	193	200	195	145	107	124	140	137	226
# of eggs hatched	53	67	87	111	108	94	28	49	79	92	94	113	62
% of eggs hatched	63	77	87	76	54	47	14	34	74	74	67	82	27
# of chicks fledged	23	35	45	70	57	51	15	29	50	51	49	60	31
% of chicks fledged	45	52	52	63	53	54	54	59	63	55	52	52	50
FLEDGE RATE	*1.15*	*1.70*	*1.80*	*1.94*	*1.32*	*1.27*	*0.36*	*1.00*	*1.85*	*1.76*	*1.58*	1.71	0.95

Table 2 summarizes nest data for the same time period. Productivity at Sandy Hook exceeded the Recovery Plan goal of 1.5 chicks/pair during 7 of the 13 years, while abundance showed an increasing trend though 1997 (severe predation event and lowest productivity recorded in 1997), then declined and remained fairly stable through 2001 and has shown an increase until 2003, when fledging rate fell to nearly half of that of 2002.

Table 2. Sandy Hook Piping Plover Nest Data (Source: J. McArthur, NPS)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
# nest attempts	23	25	28	46	59	57	63	43	31	33	36	39	63
# re-nest attempts	2	4	3	10	16	15	23	16	4	4	5	4	26
# exclosures used	16	18	20	37	51	37	28	25	21	28	34	34	42
# nests lost in laying stage	8	5	5	11	7	7	27	11	6	1	0	3	13
# eggs lost to predators	17	13	9	7	32	64	118	91	8	8	0	0	53
# excl. nests lost	5	0	0	10	21	21	22	15	3	2	7	2	8
# unhatched eggs	11	7	4	25	7	4	6	5	19	15	28	24	55

The piping plover is one of the first shorebirds to appear in spring, usually by mid-March. Early arrival date at Sandy Hook is March 10 (McArthur 2001). The birds normally depart in early September; however, they have been observed as late as September 25 (McArthur 2000-2003). The plover winters as far north as South Carolina, rarely to Maryland and southern New Jersey; very rarely to Long Island and Massachusetts (Bull 1964).

Most of the nests at Sandy Hook occur out on the open beach, seaward of the dunes, which later in the season become lightly to moderately vegetated. Nesting has historically occurred within six areas on Sandy Hook (Figure 3). Table 3 summarizes the nesting history of these sites, while Table 4 describes the nest loss by site.

Table 3. 2003 Breeding Piping Plover Abundance and Productivity by Nesting Area (Source: J. McArthur, NPS)

S to N	South Fee	Fee Beach	Hidden Beach	Critical Zone	South Gunn.	North Gunn.	North Beach	USCG	Total
# of pairs	1	6	4	4	1	5	9	8	38
# of eggs	4	45	26	14	0	34	63	40	226
# of eggs hatched	4	7	7	3	0	8	17	19	65
% of eggs hatched	100	15	27	21	0	23	25	48	29
# of chicks fledged	2	5	3	2	0	0	11	13	36
% of chicks fledged	50	71	0	1	0	0	64	68	55
FLEDGE RATE	***2.00***	***0.83***	***0.75***	***0.50***	***0.00***	***0.00***	***1.57***	***1.85***	***0.95***

Overwash habitats, bayside flats, unstabilized and recently closed inlets, ephemeral pools (areas on the beach where sea and/or rain water pool during storm overwashes and rains), and moist, sparsely vegetated barrier flats are especially important to piping plover productivity and carrying capacity in the New England, NY-NJ, and Southern Recovery Units *(e.*g., Wilcox 1959, Strauss 1990, Massachusetts Division of Fisheries and Wildlife 1996, Jones 1997, Houghton 2000, Cohen *et al.* 2002). These characteristics are indicative of optimal or highly suitable habitats.

In New York, Wilcox (1959) described the effects on piping plovers from storms in 1931 and 1938 that breached the Long Island barrier islands, forming Moriches and Shinnecock Inlets and leveling dunes across the south shore. Only three to four pairs of piping plovers nested on 17 mi. (27.4 km.) of barrier beach along Moriches and Shinnecock Bays in 1929. Following the natural opening of Moriches Inlet in 1931, plover abundance increased to 20 pairs in 2 mi. (3.2 km.) of beach habitat by 1938. In 1938, a hurricane opened Shinnecock Inlet and also eroded dunes along both Shinnecock and Moriches Bays. In 1941, plover abundance along the same 17 mi. (27.4 km.) of beach peaked at 64 pairs. Abundance then gradually decreased, a decline that Wilcox (1959) attributed to loss of habitat due to beach nourishment to rebuild dunes, the planting of beach grass, and the construction of roads and summer homes.

Ellias *et al.* (2000), in a study of nest site selection on 55.8 mi. (90 km.) of beach, stretching from Jones Beach Island to Westhampton Barrier Island, New York, found that piping plover use of ephemeral pools and bay tidal flats was greater than expected based on habitat availability. Arthropod abundances (a prey base for piping plovers), plover foraging rates, and brood survival were highest in these habitats. Ephemeral pools and tidal flats produced 51 of 81 surviving broods (63 percent), although they accounted for only 12 percent of the habitat surveyed. The authors observed that these "superior habitats" were rare in their study area and that this may be due, in part, to beach development and management practices, including attempts to stabilize beaches by means of jetty construction, breach filling, and beach renourishment. They concluded that the retention of adequate high quality habitats is important to raising piping plover productivity rates to levels that will allow the species' recovery.

Intensive management measures to protect piping plovers from disturbance by beach recreationists and their pets have been implemented at many New York-New Jersey plover nesting sites in recent years. In New York, 95.8 percent of piping plover pairs nested on non-federal land in 1999 (Rosenblatt 2000). Piping plover protection in this recovery unit, therefore, is highly dependent on the efforts of state and local government agencies, conservation organizations, and private landowners. Landowner efforts are often contingent on annual commitments. While many landowners are supportive and cooperative, others are not.

Recreational activities can be a source of both direct mortality and harassment of piping plovers. Pedestrians may flush incubating plovers from nests (Flemming *et al*. 1988, Cross 1990, Cross and Terwilliger 1993), exposing eggs to predators or excessive temperatures. Repeated exposure of shorebird eggs on hot days may cause overheating, killing the embryos (Bergstrom 1991); excessive cooling may kill embryos or retard their development, delaying hatching dates (Welty 1982). Pedestrians can also displace unfledged chicks (Strauss 1990, Burger 1991, Loegering 1992, Hoopes 1993, Goldin 1993), forcing them out of preferred habitats, decreasing available foraging time, and causing expenditure of energy.

Concentrations of beach-goers may deter piping plovers from using otherwise suitable habitat. In Jones Beach Island, New York, Ellias-Gerkin (1994) found less pedestrian disturbance in areas selected by nesting piping plovers than areas unoccupied by plovers. Burger (1991, 1994) found that presence of people at several New Jersey sites caused plovers to shift their habitat use away from the ocean front to interior and bayside habitats, and that the time plovers devoted to foraging decreased and the time spent alert increased when more people were present. Burger (1991) also found that when plover chicks and adults were exposed to the same number of people, chicks spent less time foraging and more time crouching, running away from people, and being alert then did adult birds.

Once hatched, piping plover broods are mobile and may not remain near the nesting area. Wire fencing placed around nests to deter predators (Rimmer and Deblinger 1990, Melvin *et al*. 1992) is ineffective in protecting chicks from vehicles because chicks typically leave the nest within a day after hatching and move extensively along the beach to feed. Typical behaviors of piping plover chicks increase their vulnerability to vehicles. Chicks frequently move between the upper berm or foredune and feeding habitat within the wrack line and intertidal zone. These movements place chicks in the paths of vehicles driving along the berm or through the intertidal zone. Chicks stand, walk, and run along tire ruts, and sometimes have difficulty crossing deep ruts or climbing out of them (Eddings *et al*. 1990, Strauss 1990, Howard *et al*. 1993). Chicks sometimes stand motionless or crouch as vehicles pass by, or do not move quickly enough to get out of the way (Tull 1984, Hoopes *et al.* 1992, Goldin 1993).

While loss and degradation of habitat have been major contributors to the range wide decline of the piping plover (FWS 1996b), this threat is especially prominent in the New York-New Jersey Recovery Unit. Within the New York Bight, which includes the species entire range in New Jersey and the southern Long Island shoreline, more than half the beaches are classified as "developed" (FWS 1997).

Table 4. 2003 Nest loss by Site (Source: J. McArthur, NPS)

	Fox	Human	Crow	Gull	Flood	Abandoned	Unknown
South Fee	0	0	0	0	0	0	0
Fee Beach	12	4	0	0	0	21	0
Hidden Beach	4	0	0	0	0	8	2
Critical Zone	0	0	0	0	0	7	4
South Gunnison	0	0	0	0	0	0	0
North Gunnison	20	0	0	0	0	1	1
North Beach	9	0	0	1	20	16	0
USCG	4	4	0	0	0	4	4

*Note: Abandoned or Unknown nest loss could be associated with human disturbance and/or predation.

Fee Beach: The southernmost nesting area east of the Fee Booth at the Park entrance. Public beaches north and south generate a steady flow of pedestrian traffic in the intertidal zone in front of the nesting area.

Hidden Beach: South of the nourishment site 4.6 mile (7.4 km) south of Sandy Hook Point). Public beaches north and south generate a steady flow of pedestrian traffic in the intertidal zone in front of the nesting area.

Critical Zone: The narrowest section of beach along the Sandy Hook, and most highly erosive site, is located one mile north of the park boundary and four miles south of Fort Hancock. The Critical Zone is a favored surfing site and receives significant public use.

Gunnison Beach: 1.1 mile (1.8 km) south of Sandy Hook Point, approximately 3630 feet (1.1 km) in length. The intertidal zone receives heavy pedestrian traffic throughout the week from the public beach adjacent to its boundaries. **S Gunnison** refers to the Beach

South of the groomed, public beach area and **N Gunnison** refers to the beach to the North of the groomed, public beach.

North Beach: Facing Sandy Hook Channel and the Atlantic shore at the north end of the Hook (approximately 146,200 feet (1.4-km)). Two sections, totaling 3630 feet (1.1 km) of shoreline, are fenced perpendicular to the shoreline. The 1056 feet (320 m) of shoreline between these two sections supported no shorebird nests. It may have been sub-optimal plover nesting habitat because of the narrow width of bare beach habitat (0-66 feet)(0-20 m) available at high tide. The intertidal area receives light pedestrian traffic on weekends and holidays.

Coast Guard Beach: North end of Sandy Hook (1567 feet (475 meters)). The area below Extreme High Water is subject to moderate human use throughout the week, primarily fishermen. This is an actively accreting beach.

At Sandy Hook, plovers feed at intertidal zones, wrack lines, ephemeral pools and flats, and occasionally in primary and secondary dune areas and bayside flats (McArthur 2001). Sandy Hook has limited bayside foraging habitat, and plovers nesting and feeding in the Critical Zone have been observed flying back to this bayside habitat to forage. Bayside shoreline is eroding along much of the wide northern portion of the Park and only small, narrow areas of habitat occur along the narrow, southern portion of the Park. While found primarily on the beachfronts at Sandy Hook, piping plovers also utilize back dune areas as feeding and resting areas. These areas may also be used as escape cover from predators and disturbance.

Studies suggest that the relative importance and productivity of different foraging habitats varies by site and by breeding stage (Cross, 1990, Cross and Terwilliger 2000, Coutu *et al.*, 1990, Ellias-Gerken 1994, Gibbs 1986, Goldin 1990, 1993, Hoopes 1993, Loegering 1992, McConnaughey *et al.* 1990). Studies by Houghton *et al.* (1996-2000) of West Hampton Dunes showed a preference for and higher productivity near bayside foraging habitats, as is true with other studies coast wide (Cross and Terwilliger 2000, Ellias *et al.* 2000, Ellias-Gerken and Fraser 1994, Goldin and Regosin 1998, Jones 1997, Loegering and Fraser 1995, MA Division of Fisheries and Wildlife 1996, NPS and MD DNR 1993-7, Patterson 1988, Straus 1990, Wilcox 1959).

NPS monitoring has documented that most of the plovers nest on the wide northern accreting beaches of the Hook. In recent years, due to the ACOE large-scale NJ shoreline stabilization efforts, the southern beaches have experienced less of a sand deficit and have widened, except at the severely eroding Critical Zone. Plover distribution has responded to these changing beach conditions (Table 5), as there has been a decline in nesting plovers at the Critical Zone and an increase at Monmouth and Sea Bright, where the replenished beaches have been supporting piping plovers since 1998. Abundance and productivity remain high over the 13-year period at North and Coast Guard beaches. Figure 4 depicts the rare tidal pool habitat found on these northern beaches of Sandy Hook.

Figure 4. Tidal maintenance of ephemeral pools on North and Coast Guard Beaches, 7/19/01, K. Terwilliger.

View GRAPHIC 10 File

Table 5. Number of pairs of piping plover at New Jersey nesting sites and management regions: 1991-2003. (Source: NJDEP- Jenkins, 2003)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Sandy Hook NRA:	*25*	*36*	*43*	*40*	*42*	*29*	*29*	*29*	*31*	*35*	*38*
Coast Guard	*6*	*10*	*10*	*10*	*11*	*7*	*9*	*5*	*6*	*7*	*8*
North Beach	*9*	*10*	*12*	*14*	*13*	*10*	*11*	*12*	*11*	*9*	*9*
North Gunnison	*1*	*3*	*4*	*7*	*8*	*4*	*3*	*3*	*3*	*4*	*5*
South Gunnision	*4*	*8*	*11*	*7*	*4*	*3*	*0*	*0*	*0*	*1*	*1*
Critical Zone	*5*	*5*	*6*	*2*	*0*	*0*	*0*	*0*	*1*	*2*	*4*
Hidden Beach	*0*	*0*	*0*	*0*	*6*	*4*	*4*	*3*	*3*	*5*	*4*
Fee Beach	*0*	*0*	*0*	*0*	*0*	*1*	*2*	*6*	*7*	*7*	*6*
South Fee Beach	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
Sea Bright North	0	0	0	0	0	2	4	3	3	5	7
Monmouth Beach North	0	0	0	0	1	2	3	4	4	3	2
Monmouth Beach South	0	0	0	0	0	0	0	1	1	1	0
Seven Presidents Park	0	0	0	0	0	0	0	0	0	0	1
Long Branch	0	0	0	0	0	0	0	0	0	0	1
Region 2 subtotal	**25**	**36**	**43**	**40**	**43**	**33**	**36**	**37**	**39**	**44**	**49**
Sea Girt – Wreck Pond	0	0	0	0	0	0	0	0	0	0	1
Sea Girt - NGTC	0	0	0	0	0	0	0	0	0	1	0
Mantoloking	4	5	4	3	1	0	0	0	0	0	0
Island Beach SP - Dike	0	0	0	0	0	0	0	0	0	0	2
Barnegat Light	12	9	6	5	5	2	4	3	2	3	3
Loveladies	0	1	1	1	0	0	0	0	0	0	0
Region 3 subtotal	**16**	**15**	**11**	**9**	**6**	**2**	**4**	**3**	**2**	**4**	**6**

Holgate	*14*	*15*	*10*	*11*	*11*	*17*	*24*	*19*	*19*	*14*	*13*
Little Beach	*19*	*10*	*15*	*13*	*8*	*8*	*7*	*8*	*12*	*17*	*19*
North Brigantine NA	0	0	1	5	8	8	6	11	12	15	17
Region 4 subtotal	**33**	**25**	**26**	**29**	**27**	**33**	**37**	**38**	**43**	**46**	**49**
Brigantine Beach	8	4	5	5	2	0	0	0	0	0	0
Brigantine - Inlet (Cove)	0	1	1	0	0	0	0	0	0	1	0
Ocean City - North	1	2	3	4	4	3	4	5	8	8	2
Ocean City - Center	0	3	3	5	5	6	7	8	9	8	8
Region 5 subtotal	**9**	**10**	**12**	**14**	**11**	**9**	**11**	**13**	**17**	**17**	**10**
Corson's Inlet SP	5	5	3	2	3	0	1	1	1	1	2
Strathmere (Upper Twp.)	6	3	2	1	0	0	0	0	0	0	1
Whale Beach	4	4	5	2	2	1	0	0	0	1	0
Sea Isle - North	3	2	2	3	1	0	0	0	0	0	0
Sea Isle - South	3	4	3	3	2	0	0	0	1	0	0
Townsend's Inlet	1	1	0	0	0	0	0	0	1	1	1
Avalon – North	5	4	3	2	3	1	1	1	1	0	0
Avalon - Dunes	3	1	2	4	3	2	4	3	4	7	8
Region 6 subtotal	**30**	**24**	**20**	**17**	**14**	**4**	**6**	**5**	**8**	**10**	**12**
Stone Harbor Point	0	0	0	0	0	0	3	5	5	6	6
N. Wildwood - Hereford	0	0	0	0	0	0	0	0	0	3	3
N. Wildwood - Oceanfront	5	2	2	1	0	0	0	0	0	0	0
Wildwood Crest	0	0	0	0	0	1	0	0	0	0	0
Coast Guard - LSU[1]	0	1	0	0	0	0	0	1	1	*2*	*2*
Coast Guard - TRACEN	6	7	6	7	3	3	5	5	2	3	4
Cape May City	0	0	0	0	1	1	1	1	2	1	0
Cape May Meadows	*3*	*4*	*12*	*10*	*9*	*7*	*4*	*4*	*3*	*2*	*3*
The Nature Conservancy	*3*	*3*	*11*	*9*	*8*	*7*	*4*	*3*	*2*	*2*	*2*
Cape May Point SP[2]	0	1	1	1	1	0	0	1	1	0	1
Region 7 subtotal	**14**	**14**	**20**	**18**	**13**	**12**	**13**	**16**	**13**	**17**	**18**
Total Pairs	**127**	**124**	**132**	**127**	**114**	**93**	**107**	**112**	**122**	**138**	**144**
Pairs at NJDFW sites	**66**	**59**	**52**	**53**	**44**	**32**	**43**	**52**	**57**	**68**	**70**

[1] Prior to 2002, this site was co-monitored by NJDFW.
[2] This site was tabulated as a NJDFW site beginning in 2003.
Note: Sites in italics monitored by agencies other than NJDFW.

Sandy Hook has an established management plan to protect the piping plover (NPS 1992) on the Park. This plan follows and incorporates all of the recommendations provided by the FWS to NPS in 1992 during informal consultation. Those ten management actions form the foundation of the NPS Sandy Hook plover management plan.

NPS Management for human disturbance established six protected areas that contain all of the nesting piping plovers (as well as other rare beach flora and fauna). These areas comprise almost 50% of the Sandy Hook Shoreline and about 90% of the wide, northern beaches. Although piping plover use of Gunnison and North Beach public beaches has not been observed, the NPS will consult with the FWS should nesting occur. Off-road-vehicles are prohibited year round, and dogs are prohibited on ocean beaches from March to September to protect piping plovers. NPS personnel at Sandy Hook and Gateway's Division of Natural Resources monitor all potential predators and activities that may harm or harass breeding piping plovers.

In spite of the protected area establishment and enforcement, major declines in productivity resulted from severe predation in 1995-1998. Exclosures have been placed around all nests that existing staff can set up and monitor according to proper protocol and guidelines. Predator populations have not been monitored year round, but it appears that their populations peaked and a few "smart fox" (*Vulpes vulpes*) significantly affected productivity during that three-year period (J. McArthur 2001-2003). Weather and flooding events have also contributed more recently to nest failure. Most notable in the high flooding and abandonment rate in 2003. 2003 survey results indicate the highest numbers recorded to date. Regions and sites (Jenkins and Pover 2003), however varied over the years.

Seabeach Amaranth

Seabeach amaranth was added to the List of Endangered and Threatened Wildlife and Plants as a threatened species in 1993. The listing was based upon the loss of seabeach amaranth from two-thirds of its historic range, and continuing threats to the 55 populations that remained at the time (FWS 1993). No critical habitat, as defined under the ESA, has been designated for this species.

Seabeach amaranth is an annual plant of the Amaranth family (Amaranthaceae). Upon germination, the plant initially forms a small, unbranched sprig, but soon begins to branch profusely, forming a low-growing mat. Seabeach amaranth's fleshy stems are prostrate at the base, erect or somewhat reclining at the tips, and pink, red, or reddish in color. The leaves of seabeach amaranth are small, rounded, and fleshy, spinach-green in color, with a characteristic notch at the rounded tip. Leaves are approximately 1.3 to 2.5 cm in diameter, and clustered towards the tip of the stem (Weakley and Bucher 1992). The foliage of seabeach amaranth turns deep red in the fall (Snyder 1996). Plants often grow to 30 cm in diameter, consisting of 5 to 20 branches, but occasionally reach 90 cm in diameter, with 100 or more branches. Flowers and fruits are inconspicuous, borne in clusters along the stems. Seeds are 2.5 millimeters (mm) in diameter, dark reddish-brown, and glossy, borne in low density, fleshy, indehiscent utricles (bladder-like seed capsules or fruits), 4 to 6 mm long (Weakley and Bucher 1992). The seed does not fill the utricle, leaving an air-filled space (FWS 1996a).

Many utricles remain attached to the parent plant and are never dispersed, leading to *in situ* planting. This phenomenon has also been observed in sea rocket and may be an adaptation to dynamic beach conditions. If conditions remain favorable at the site of the parent plant, then seed source for retention of that site is guaranteed. When habitat conditions become unsuitable, other seeds have been dispersed to colonize new sites (Weakley and Bucher 1992).

Individual plants live only one season with only a single opportunity to produce seed. The species overwinters entirely as seeds. Germination of seedlings begins in April and continues at least through July. In the northern part of the range, germination occurs slightly later, typically late June through early August. Reproductive maturity is determined by size rather than age and flowering begins as soon as plants have reached sufficient size. Even very small plants can flower under certain conditions. Flowering sometimes begins as early as June in the Carolinas but more typically commences in July and continues until the death of the plant. Seed production begins in July or August and reaches a peak in most years in September. Seed production likewise continues until the plant dies. Senescence and death occur in late fall or early winter (FWS 1996a, 2002a and b). While seabeach amaranth seems capable of essentially indeterminate growth (Weakley and Bucher 1992), predation and weather events, including rainfall, hurricanes, and temperature extremes, have significant effects on the length of the species' reproductive season. As a result of one or more of these influences, the flowering and fruiting period can be terminated as early as June or July (FWS 1993).

Seabeach amaranth is native to Atlantic coast barrier island beaches from Massachusetts to South Carolina. The species primary habitat consists of overwash flats at accreting ends of barrier islands, and lower foredunes and upper strands of non-eroding beaches. This species occasionally establishes small, temporary, and casual populations in secondary habitats including sound side beaches, blowouts in foredunes, and sand or shell dredge spoil or beach nourishment material (Weakley and Bucher 1992).

Seabeach amaranth occupies a narrow beach zone that lies at elevations from 0.2 to 1.5 m above mean high tide, the lowest elevations at which vascular plants regularly occur. Seaward, the plant grows only above the high tide line, as it is intolerant of even occasional flooding during the growing season. Landward, seabeach amaranth does notoccur more than a meter or so above the beach elevation on the foredune, or anywhere behind it, except in overwash areas. The species is, therefore, dependent on a terrestrial, upper beach habitat that is not flooded during the growing season. This zone is absent on beaches that are experiencing high rates of erosion. Seabeach amaranth is never found on beaches where the foredune is scarped by undermining water at high or storm tides (Weakley and Bucher 1992).

Seabeach amaranth usually occurs on a pure silica sand substrate, occasionally containing shell fragments. The U.S. Natural Resources Conservation Service classifies the habitat of seabeach amaranth as either Beach-Foredune Association or Beach (occasionally flooded). The habitat of seabeach amaranth is sparsely vegetated with annual herbs and, less commonly, perennial herbs (mostly grasses) and scattered shrubs.

Seabeach amaranth does not occur on well-vegetated sites, particularly where perennials have become strongly established (Weakley and Bucher 1992). Seabeach amaranth seems to be incapable of competing with other plants and is typically found in areas with little or no vegetation. Except where suitable habitat has persisted long enough for perennials to become established, the primary limiting factors of seabeach amaranth under natural conditions are abiotic.

Abiotic limiting factors are expected for a fugitive species that occupies dynamic, early successional habitats. Weather is an important limiting factor, given the relatively narrow temperature and rainfall requirements for germination and seedling establishment. Flooding, drought, or unseasonable temperatures may impair seabeach amaranth survival and reproduction. Weather also limits abundance of the species through its effects on winds, which may cause burial of seeds and plants by sand. In addition to decreasing germination and seedling establishment, burial may also impact reproduction by covering adult plants prior to seed set.

Coastal storms are probably the single most important natural limitation on the abundance of seabeach amaranth. Storms erode habitat and curtail the reproductive season due to flooding and overwash. However, storm events also permit the species to survive by creating new habitat, and by providing long-distance seed transport. Through these combined effects, storms largely determine the distribution of the species in the landscape. A patchy distribution may itself limit the abundance of seabeach amaranth; colonization of suitable habitats is hampered by long distances to the nearest seed source (Weakley and Bucher 1992).

The primary threats to seabeach amaranth are the adverse alterations of habitat caused by beach erosion and shoreline stabilization. Although seabeach amaranth does not persist on eroding beaches, erosion is not a threat to the continued existence of the species under natural conditions. Erosion in some areas is balanced with habitat formation elsewhere, such as accreting inlets and overwash areas, resulting in an equilibrium that allows the plant to survive by moving around in the landscape. In the geologic past, seabeach amaranth has persisted through even relatively rapid episodes of sea level rise and barrier island retreat. A natural barrier island landscape, even a retreating one, contains localized accreting areas, especially in the vicinity of inlets (FWS 1996a).

Human alteration of the barrier island ecosystem generally tips the equilibrium between habitat destruction and creation in favor of destructive erosional forces. Erosion is accelerated in many areas by human-induced factors such as reduced sediment loads reaching coastal areas due to damming of rivers, and beach stabilization structures. When the shoreline is “hardened” by artificial structures *(e.g.* seawalls, bulkheads), overwash and inlet formation are curbed. Erosion may also be increasing due to sea level rise and increased storm activity caused by global climate change (FWS 1993).

Although storms and erosion threaten seabeach amaranth, attempts to stabilize beaches against these natural processes are generally more destructive to the species and to the beaches themselves in the long term (FWS 1993). Any stabilization of the shoreline is generally detrimental to a pioneer, upper beach annual, whose niche or “life strategy” is the colonization of unstable, unvegetated, new land, and which is unable to compete with perennial grasses (FWS 1996a).

Attempts to halt beach erosion through hard structures *(i.e.*, sea walls, jetties, groins, bulkheads) appear invariably to destroy habitat for seabeach amaranth. Even minor structures and non-structural beach stabilization techniques, such as sand fences and beach grass planting, are generally detrimental to seabeach amaranth (FWS 1993). Dune stabilization and vertical sand accretion caused by sand fences appear to be detrimental to seabeach amaranth and contradictory to its life history strategy. The effects of dune stabilization by planting vegetation are similar (FWS 1996a). Seabeach amaranth only very rarely occurs when sand fences and vegetative stabilization have taken place and, in these situations, is present only as rare, scattered individuals or short-lived populations (Weakley and Bucher 1992).

Beach nourishment can have positive site-specific impacts on seabeach amaranth. Although more study is needed before the long-term impacts can be accurately assessed, seabeach amaranth has colonized several nourished beaches, and has thrived in some sites through subsequent re-applications of fill material (FWS 1993). However, on the landscape level, beach nourishment is similar to other beach stabilization efforts in that it stabilizes the shoreline and curtails the natural geophysical processes of barrier islands.

These effects are detrimental to the range-wide persistence of the species. In addition, beach nourishment may cause site-specific adverse effects by crushing or burying seeds or plants, or by altering the beach profile or upper beach micro-habitats in ways not conducive to seabeach amaranth colonization or survival. Deeply burying seeds during any season can have serious effects on populations; this also applies to the placement of dredge spoil (FWS 1996a). Burial of the seed bank may be particularly detrimental to isolated populations, as no nearby seed sources are available to re-colonize the nourished site. Adverse effects of beach nourishment may be compounded if accompanied by artificial dune construction and stabilization with sand fencing and/or beach grass, or if followed by high levels of erosion and scarping of the upper beach.

Seabeach amaranth was last recorded in NJ in 1913 and in Monmouth County in 1899 (FWS 2001), but was rediscovered in July 2000. It is considered by the NJ Natural Heritage Program to be globally rare (G2), and has recently been rediscovered in 5 of the nine states in which historic records occurred. Table 6 and Figure 3 depict the population distribution of these newly documented populations in NJ.

Table 6. Amaranth Survey results, 2000-2003. Source: NPS and FWS

Location	**Total # of plants in year:**			
	2000	**2001**	**2002**	**2003**
S. Fee Beach	0	0	0	225
Fee Beach	41	192	225	128
Hidden	57	285	536	139
Critical Zone	7	53	98	370*
Lot D	0	0	0	0
Lot E	0	0	0	0
north of F lot	8	25	12	0
South	1	5	15	2
North	6	0	11	2
North Beach	0	0	2	0
USCG Beach	0	1	5	1
Total:	**120**	**561**	**904**	**867***

* 325 plants at the Critical Zone were planted.

Seabeach amaranth is a very rare plant at Sandy Hook. The plant had been absent in the Park for nearly 100 years and recently reappeared in 2000, primarily in areas receiving beach fill (Figure 3). Seabeach amaranth, a brittle annual plant growing on fragile beaches, may have been decimated over much of its former range by the increasing impacts of beach development and usage in recent decades (FWS 1993). At Gateway NRA, fencing that protected piping plovers and other shorebird nesting areas has favored seabeach amaranth by reducing access by off road vehicles and pedestrians (Stalter 1995). Numbers have increased presumably due to the accreting beach and neighboring sand and seed source immediately to the south. In 2003, 325 plants were planted and are presently being monitored.

Amaranth plants flower from mid-summer to late fall and produce seeds from July or August until mortality, now found to be as late as December (FWS 2002, 2003). It has been found to grow in concentrated areas in and around the wrack line of material deposited by the highest spring tides. The plants can produce hundreds of seeds that are distributed by wind and water to new locations (NPS 1998). Seeds retained in utricles are easily blown about, deposited in depressions, the lee behind plants, or in the surf. Naked seeds are also commonly encountered in the field and are also dispersed by wind, but to a much lesser degree than seeds retained in utricles. Naked seeds tend to remain in the lee of the parent plant or get moved to nearby depressions (Weakley and Bucher 1992). Observations from South Carolina indicate that seabeach amaranth seeds are also dispersed by birds through ingestion and eventually deposited with their droppings (Hamilton 2000b).

Density of seabeach amaranth is extremely variable within and between populations. The species generally occurs in a sparse to very sparse distribution pattern, even in the most suitable habitats. A typical density is 100 plants per linear km. of beach, though occasionally on accreting beaches, dense populations of 1,000 plants per linear km. of beach can be found. Island-end sand flats generally have higher densities than oceanfront beaches (Weakley and Bucher 1992). Seabeach amaranth has been found to have a strongly clumped distribution (Hancock 1995). On Long Island, New York, however, dense assemblages and high abundances have been recorded on central barrier island locations (Young 2002).

Within its primary habitats, seabeach amaranth concentrations can be found in the wrackline (Mangels 1991, Weakley and Bucher 1992, Hancock 1995, MacAvoy 2000). In 2001, a study by Pauley *et al.* (1999) suggested that organic litter may be an advantageous microhabitat for seabeach amaranth when it contains higher levels of organic material and moisture than bare sand.

Weakley and Bucher (1992) completed range-wide surveys of seabeach amaranth at known historical sites in 1987 and 1988. In 1987, 39 populations contained a total of 11,740 plants. In 1988, 45 populations contained a total of 43,651 plants, representing a one-year increase of 372 percent. A survey in 1990 revealed 43 populations with a total of 11,075 plants in the Carolinas plus an additional 13 populations with 357 plants which reappeared on Long Island, New York (Clements and Mangels 1990). Even with the addition of the New York populations, the 1990 survey documented a range-wide reduction of 74 percent from the 1988 census.

Due to the limited number of surveys, consecutive data over the last three years (2000-2002) was only available for the states of Delaware, New Jersey, and New York. In New York State, the New York State Natural Heritage Program (NYSNHP) has collected data over the last 13 years (Table 6). Data (approximate number of plants) for Delaware and

New Jersey are listed in Table 7. Data are available for several other states for the 2002 growing season, including Virginia (20 plants), North Carolina (2,001 plants), and South Carolina (199 plants); however, surveys were limited to only several historic sites and not considered complete.

The 2000 population of seabeach amaranth had an uneven geographic distribution, with almost 99 percent of the plants located on Long Island, New York. A single site on Long Beach Island, New York, comprised 75 percent of the total plants range-wide. Of the 39 extant sites documented in 2000, eleven had 100 or more plants (seven in New York, two in New Jersey, and two in North Carolina), and four had 1,000 or more plants (all in New York). Seventeen sites had fewer than ten plants (three in New York, one in Maryland, eleven in North Carolina, and two in South Carolina) (Young 2003, MacAvoy 2000, NPS 2001a, 2001b, Jolls and Sellers 2000, U.S. Army Corps of Engineers 2001b, Hamilton 2000a).

Historically, seabeach amaranth occurred in nine states from Massachusetts to South Carolina. The populations which have been extirpated are believed to have succumbed as a result of hard shoreline stabilization structures, erosion, tidal inundation, and possibly as a result of herbivory by webworms (FWS 1994b). The continued existence of the plant is threatened by these activities (Ellias-Gerken 1994; Van Schoik and Antenen 1993) as well as the adverse alteration of essential habitat primarily as a result of “soft” shoreline stabilization (beach nourishment, artificial dune creation, and beach grass plantings), but also from beach grooming and other causes (Murdock 1993).

Populations of seabeach amaranth at any given site are extremely variable (Weakley and Bucher 1992) and can fluctuate by several orders of magnitude from year to year. The primary reasons for the natural variability of seabeach amaranth are the dynamic nature of its habitat and the significant effects of stochastic factors such as weather and storms on mortality and reproductive rates. Although wide fluctuations in species populations tend to increase the risk of extinction, variable population sizes are a natural condition for seabeach amaranth and the species is well adapted to its ecological niche.

In 2002, 904 plants were found on Sandy Hook, of which, 98 were located in the Critical Zone. In 2003, a total of 867 plants were located on Sandy Hook during an August survey. Of those 45 were found in the Critical Zone and another 325 plants were planted.

NPS monitors this species in conjunction with FWS and NJDEP annually as summer/fall surveys. Plants occur within the protected areas and are afforded the same protection as plovers and terns by the symbolic fencing and signs. NPS, as in neighboring beaches, coordinated with FWS through informal consultation to minimize and mitigate impacts to these populations by following the protocol established for the ACOE at Fire Island Inlet (letters dated 7/2/01 from D. Stillwell and J. Tovolaro dated 7/31/01) for a pending beach replenishment project.

The primary threats to seabeach amaranth are the adverse alterations of habitat caused by beach erosion and shoreline stabilization. Although seabeach amaranth does not persist on eroding scarped beaches, erosion is not a threat to the continued existence of the species under natural conditions. Erosion in some areas is balanced with habitat formation elsewhere, such as accreting inlets and overwash areas, resulting in an equilibrium that allows the plant to survive by moving around the landscape. Seabeach amaranth has persisted through even relatively rapid episodes of sea level rise and barrier island retreat. A natural barrier island landscape, even a retreating one, contains localized accreting areas, especially in the vicinity of inlets (FWS 1996a).

Human alteration of the barrier island ecosystem generally tips the equilibrium between habitat destruction and creation in favor of destructive erosional forces. Erosion is accelerated in many areas by human-induced factors such as reduced sediment loads reaching coastal areas due to damming of rivers and beach stabilization structures. When the shoreline is "hardened" by artificial structures *(e.*g., seawalls and bulkheads), overwash and inlet formation are curbed. Erosion may also be increasing due to sea level rise and increased storm activity caused by global climate change (FWS 1993).

Although storms and erosion threaten seabeach amaranth, attempts to artificially stabilize beaches against these natural processes are generally more destructive to the species and to the beaches themselves in the long-term (FWS 1993). Structural and non-structural beach stabilization techniques, such as beach nourishment, sand fences and beach grass planting, are generally detrimental to seabeach amaranth, a pioneer, upper beach annual, whose niche or "life strategy" is the colonization of unstable, unvegetated new land (FWS 1996a). Seabeach amaranth only very rarely occurs when sand fences and vegetative stabilization have taken place and, in these situations, is present only as rare, scattered individuals or short-lived populations (Weakley and Bucher 1992).

Beach nourishment can have positive site-specific impacts on seabeach amaranth. Although more study is needed before the long-term impacts can be accurately assessed, seabeach amaranth has colonized several nourished beaches and has thrived in some sites through subsequent reapplications of fill material (FWS 1993). On the landscape level, beach nourishment is intended to stabilize the shoreline and curtail the natural geophysical processes of barrier islands, something which is detrimental to the range-wide persistence of the species. Beach nourishment projects may cause site-specific adverse effects by crushing or burying seeds or plants or by altering the beach profile or upper beach microhabitat in ways not conducive to colonization or survival. Deeply burying seeds during any season can have serious effects on populations (FWS 1996a), particularly to isolated populations, as no nearby seed sources are available to re-colonize the nourished site. Adverse effects of beach nourishment may be compounded if accompanied by artificial dune construction and dune stabilization with sand-fencing and/or beach grass or followed by high levels of erosion and flooding of the upper beach, which create scarped conditions.

Seabeach amaranth is vulnerable to habitat fragmentation and isolation of small populations (FWS 1993). Fifty to 75 percent of coastlines have been rendered "permanently" unsuitable. This makes it increasingly more difficult to recover the species because any given area will become unsuitable at some time due to natural forces. If a seed source is no longer available in the vicinity, seabeach amaranth will be unable to reestablish itself when the area once again provides suitable habitat. In this way, the species can progressively be eliminated even from generally favorable stretches of habitat surrounded by “permanently” unfavorable areas. Fragmentation of habitat in the northern part of the species range apparently led to regional extirpation during the last century. Areas of suitable habitat were separated from one another by distances too great to allow recolonization following natural catastrophes (Weakley and Bucher 1992).

New York and New Jersey beaches have been especially affected by past and ongoing habitat modification. New Jersey has the highest degree of shoreline stabilization of any state. As measured by the amount of shoreline in the totally stabilized category (90 to 100 percent "walled"), New Jersey, America's oldest developed shoreline, is 43 percent hard-stabilized (Pilkey and Wright 1988). Much of New York is included in current or proposed long-term beach nourishment programs. Cumulatively, these nourishment projects contribute significantly to the stabilization of the NY-NJ shoreline. Furthermore, multiple, simultaneous disturbances to the habitats upon which this species depends increase the vulnerability of seabeach amaranth to declining habitat conditions and catastrophic events. These factors are particularly important given the recent seabeach amaranth population shift from south to north, discussed further below.

Beach grooming, more common on northern beaches, may also have contributed to the previous extirpation of seabeach amaranth from that part of its range. Motorized beach rakes, which remove trash and vegetation from bathing beaches, do not allow seabeach amaranth to colonize long stretches of beach (FWS 1996a). In New Jersey, plants were found along a nearly continuous length of beach, noticeably interrupted by stretches that are routinely raked.

Predation by webworms (caterpillars of small moths) is a major source of mortality and lowered fecundity in the Carolinas, often defoliating plants by early fall (FWS 1993). Defoliation at this season appears to result in premature senescence and mortality, reducing seed production, the most basic and critical parameter in the life cycle of an annual plant. Webworm predation may decrease seed production by more than 50 percent (Weakley and Bucher 1992). In New York, herbivory by saltmarsh caterpillars *(Estigmene acrae*a) has been observed (FWS 1996a). Webworm herbivory of seabeach amaranth has not been documented in Delaware or Maryland. Overall, webworm herbivory is probably a contributing, rather than a leading factor, in the decline of seabeach amaranth. In combination with extensive habitat alteration, severe herbivory could threaten the existence of the species (Weakley and Bucher 1992).

Seabeach amaranth is generally not threatened by over-utilization or collection, as it does not have showy flowers and is not a component of the commercial trade in native plants. However, because the species is easily recognizable and accessible, it is vulnerable to taking on Federal lands, vandalism, and the incidental trampling by curiosity seekers. Seabeach amaranth is an attractive and colorful plant, with a prostrate growth habit that could lend itself to planting on beach front lots. The species effectiveness as a sand binder could make it even more attractive for this purpose. In addition, seabeach amaranth is being investigated by the U.S. Department of Agriculture and several universities and private institutes for its potential use in crop development and improvement. Over-collection and the development of genetically-altered, domesticated varieties are potential, but currently unrealized, threats to the species (FWS 1993).

New threats (mammalian and avian herbivores and disease) to seabeach amaranth have been documented since the species was listed in 1993. These factors are lesser threats than habitat modification, but may increase the risk of extinction by compounding the effects of other, more severe threats. Several additional herbivores of seabeach amaranth have been observed including white-tailed deer *(Odocoileus virginianu*s), rabbits *(Sylvilagus floridanu*s), and migratory songbirds (Van Schoik and Antenen 1993).

The first known disease of seabeach amaranth was documented in South Carolina in 2000. During the 2000 growing season, an oomycete *(Albugo* spp.) was observed on seabeach amaranth in several South Carolina sites (Strand and Hamilton 2000). This pathogen is a white rust or water mold. Effects on infected individuals were significant, resulting in death of the plants two to four weeks after lesions were first observed. Anecdotal observations suggest that isolated plants tended to avoid infection (Strand and Hamilton 2000).

Northeastern Beach Tiger Beetle

The northeastern beach tiger beetle has white to light tan wing covers on it's back that are often marked with fine dark lines. The head and thorax (chest area) are bronze-green. Overall length varies from 1/2 to 3/5 inch (13-15.5 mm). They grasp prey with long, sickle-like mandibles (mouthparts) in an aggressive, "tiger-like" manner. Larvae are also predatory and similarly equipped (New York Department of Environmental Conservation (NYDEC) 2003).

Northeastern beach tiger beetles have a full, two-year life cycle. Adults emerge in late June, reach peak abundance by mid-July, and decline through early September. They feed, mate and bask at the water's edge on warm, sunny days. Some adults are also active on warm, calm evenings. High body heat is necessary for maximum predatory activity. Foraging occurs in the damp sand of the intertidal zone; prey species include lice, fleas, and flies. Adults also regularly scavenge dead crabs and fish (FWS 1990, NYDEC 2003).

Mating and egg-laying occur from late-June through August. Females deposit their eggs in the sand after mating, higher up the beach in the dunes. Eggs hatch and larvae appear in late July and August. Larvae experience three developmental stages or "instars." Most larvae reach the second instar by September and a few reach the third instar well into November, when larvae are still active (FWS 1990, NYDEC 2003).

Most overwinter as second instars. Next year, these same individuals overwinter again, this time as third instars. Overwintering occurs high up the beach; storms and wave activity are thus avoided. Both second and third instars emerge from winter inactivity in mid-March. Third instar larvae emerge, pupate in the bottom of their burrows, and re-emerge as winged adults in June, two full years after the eggs were laid (FWS 1990, 2002; NYDEC 2003).

Larvae live in vertical burrows located in the upper intertidal to high drift zone, where prey is most abundant. Larvae forage from their burrows, preying on passing insects. Their primary food sources are beach fleas, lice, flies and ants. Larvae are regularly covered during high tide; sand moisture is important. Larvae lack a hard shell and are subject to desiccation. They avoid hot, dry conditions. During the summer months they are inactive, going through a period of aestivation. With each successive stage of development, larvae grow in size and burrow deeper, going from 4 to 6-7 to 9-14 inches into the sand (FWS 1990, NYDEC 2003).

Populations of tiger beetles normally experience very high larval mortality and dramatic year-to-year, two to three fold fluctuations in abundance, sometimes resulting in local extinction. Weather factors such as flood tides, hurricanes, erosion and winter storms, mortality due to predators and parasites, and recreational beach use all contribute to the population declines. Natural enemies of adults include robber flies (Asilidae), birds and spiders. Larvae are preyed upon by parasitic, wingless wasps (Methocha), which lay their eggs on the tiger beetle larvae. The larval wasps develop by eating the larval tiger beetles (FWS 1990, 2002; NYDEC 2003).

Early records indicate that the northeastern beach tiger beetle occurred in "great swarms in July" along coastal beaches from Martha's Vineyard south to New Jersey and on both sides of Chesapeake Bay in Virginia and Maryland. Ideal habitat for the adult beetles and their larvae are wide, undisturbed, dynamic, fine sand beaches. The most important consideration, though, is limited use and disturbance by vehicles and humans (FWS 1990, NYDEC 2003).

The northeastern beach tiger beetle is currently extirpated from New York State. During the last 20 years, the beaches on Long Island have been subject to increasing vehicular traffic. Surf fishermen, commercial seiners, and beach recreationists in general use 4-wheel-drive trucks and other off-road vehicles on the beaches, especially in the intertidal zone. Foot traffic can be heavy. The impacts on larvae can be considerable, compacting burrows and crushing individuals. The fact that the tiger beetle is in the larval stage for two years increases the significance of these disturbances (FWS 1990, 2002, NYDEC 2003).

Although there are many populations in the Chesapeake Bay area, most are threatened by activity associated with human population increases. Developmental pressure with concurrent beach alteration, beach stabilization structures, and recreational activities, has greatly altered the beetle's habitat along the Atlantic Coast. The continual disturbance or disruption of occupied habitats has eliminated many populations. A series of nearby or contiguous populations is probably necessary to naturally re-establish populations that have been locally depleted or extirpated. The decrease in habitat availability and a reduced number of populations make it difficult for beetles to recover from population declines. Long-term survival of this species is probably dependent upon its ability to disperse for considerable distances to colonize transient or well separated habitats, something which is perhaps unlikely without outside help. While mark-recapture study results have shown the beetles capable of traveling 5-12 miles from their original capture site, it might not be enough to reach the nearest suitable habitat (FWS 1990, NYDEC 2003).

The natural balance between the beetles and their primary predators has also been altered by habitat degradation and other factors. In some cases, these natural enemies may now pose a significant threat to the beetles.

Detailed knowledge of certain aspects of distribution, annual and seasonal abundance, and ecology have only recently been gained, but more research is still needed. The objective of recovery efforts is to restore this threatened species to a secure status within its historical range. This could be accomplished by translocating beetles as has been done on Sandy Hook since 1997 (NJDEP 2002, FWS 2002). Reestablishment methodology needs to be developed and survivorship maximized.

The northeastern beach tiger beetle, a federally threatened species (FWS 1990) and a state endangered species (NJDEP 2002) was reintroduced on the northern section of Sandy Hook as part of the recovery efforts for this species (Knisley and Hill 1996, 1997, 2000) (Figure 3). Tiger beetle larvae from the Chesapeake Bay area were translocated to several beach sites within the recreation area and routinely monitored. Initial results from the experiments indicated that the translocation techniques employed could be used to establish a population of northeastern beach tiger beetles at Sandy Hook and possibly at other sites in the Northeast (Knisley and Hill 1997).

No tiger beetle adults or larvae have been reported from other areas of Sandy Hook except the reintroduction area on North Beach. Because the beetle occurs outside the project area, and is not expected to be adversely impacted, its status is not discussed in more detail.

The northeastern beach tiger beetle receives regulatory protection from both federal and state Endangered Species Acts. In addition, habitat protection is afforded through the Coastal Areas Facilities Review Act and other coastal regulations.

NPS monitors this species in coordination with FWS though annual surveys. Adult populations are estimated to be around 500 individuals according to annual surveys (Knisley 2000). Table 7 shows the results of surveys for the larvae and adult beach tiger beetles conducted annually from 1994-2003. The population is protected by symbolic fencing and signs, as it occurs within the North and Coast Guard Beach protected areas. These beaches are accreting and receive low human use. NPS plans include the long-term protection of these beaches as outlined and confirmed by FWS (2002) reinforcing the original intent for the reintroduction. NPS management for the beetles remains consistent, and survey and protection efforts will continue, as coordinated annually with FWS staff.

Recent trends in survey results are puzzling and highly variable. Marked low numbers were reported both in 2001 and 2003. Reasons for this variable survey results are not known, however, survey effort and timing might be a factor to consider. Large numbers of loafing/roosting gulls were also recorded during a tiger beetle survey when low beetle numbers were recorded (FWS 2002).

Table 7. Results of Northeastern Beach Tiger Beetle surveys, 1994-2003. Source: NPS, FWS

Observation Date	Larvae Released	Adults Observed
October 1994	400	N/A
July 1995	0	48
October 1995	219	N/A
July 1996	0	18
May 1997	486	N/A

July 1997	0	178
July 1998	0	50
May 1999	585	N/A
July 1999	0	259
August 1999	0	80
May 2000	554	N/A
July 2000	0	955
2001	N/D	N/D
July 2002	0	188
August 2002	0	70
July 2003	0	57

N/D = no data

Other Rare Beach Species on Sandy Hook

Seabeach Knotweed

Seabeach knotweed is a rare plant listed as endangered by the State of New Jersey. It is an herb with prostrate to erect branching stems having alternate whitish leaves up to 3 cm long, crowded along branches with axillary clusters of small inconspicuous flowers. Seabeach knotweed begins flowering and seed dispersal during July and continues through October when the plants die. It is often found on sandy beaches, brackish swales, and the edge of salt marshes.

This species has only been documented on two other occasions on Sandy Hook. While conducting surveys for seabeach amaranth, seven (7) seabeach knotweed plants were found in the Critical Zone. Since they occur in the same area and habitat as seabeach amaranth, the NPS plans to provide the same protection and management as the federally threatened amaranth species.

Least Tern

This water bird is listed as endangered by the State of New Jersey, NJ DEP, Division of Fish Game and Wildlife, Endangered Non-game Species Unit. It is a small, white and black water bird that breeds in colonies, usually on the supratidal beach habitat. Least terns have similar nesting requirements to piping plovers, but tend to require wider beaches and use larger areas of sparsely vegetated dunes. All colonies now occur within the large protected areas that also contain plovers, amaranth and/or tiger beetle. The same conservation measures used for piping plover are employed for any least tern nests or colonies located on the new fill including public use closures through symbolic fencing.

Least tern colony numbers have been variable on Sandy Hook (Table 8). Least terns nested on the dredge fill placed at the Critical Zone following large fill projects.

Colonies were observed there in 1990–1996, 1998 and 2003. The larger colonies now occur on Fee and Hidden beaches but are also found on N Gunnison, North and Coast Guard Beaches (Table 9).

Table 8. Least Terns at Sandy Hook, 2003; Source: J. McArthur

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
# PAIRS	161	99	172	233	305	80	158	76	129	188	194	222	72
# YOUNG	48	13	19	31	35	8	28	28	124	57	74	52	9

Table 9. 2003 Shorebird and Water bird numbers of pairs/young fledged by nesting locations; Source: J. McArthur, NPS

Species	S. Fee	Fee	Hidden	Critical	S. Gunn	N. Gunn	N. Beach	USCG	Total
Least Tern	9 / 1	28 / 5	8 / 0	66 / 2	0 / 0	2 / 0	4 / 0	26 / 1	**143 / 9**
Oystercatcher	0 / 0	2 / 0	2 / 0	2 / 0	4 / 0	4 / 0	2 / 2	2 / 0	**18 / 0**
Common Tern	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	4 / 0	4 / 0	4 / 0	**8 / 0**
Piping Plover	2 / 2	12 / 5	8 / 3	8 / 2	2 / 0	10 / 0	14 / 11	14 / 13	**70 / 36**

The state of NJ also lists the red knot (*Calidris canutus*) and osprey (*Pandion haliaetus*) as protected species, but they occur outside the project window or habitat, and because of their behavior and ecology, should not be adversely affected by the project.

Sea Turtles and Marine Mammals

Sea turtles and marine mammals potentially occur within the project area, but due to the project timing, they are not expected to be present or impacted by the project during the October 1- February 1 window. In addition, the location and size of the eductor equipment along with its protective encasement and screen would avoid and minimize any reasonable possibility for impact or mortality to even the smallest of these species or individuals.

Three species of endangered whales—the finback (*Balaenoptera physalus*), humpback (*Megaptera novaeangliae*), and the right whale (*Balaena glacialis*)—have the potential to pass through the waters above the borrow area. All three species are state and federally listed endangered species. They are found significantly farther offshore, but have the (limited) potential to enter the area during spring and fall migration periods. No records, present or past, indicate that the New York Bight is a high use foraging area for large cetaceans. The finback whale is the most abundant species and occurs year round in the New York Area, although it peaks in the spring and summer months. Finbacks occur in both deep and shallow water (Blaylock *et al.* 1995, NMFS 1995).

Northeast waters provide important developmental habitat for sea turtles during the warmer months (Shoop and Kenney 1992, Ruben and Morreale 1999). The turtles recorded in the northeastern nearshore waters are small juveniles and are predominated by loggerhead (*Caretta caretta*) and Kemp's Ridley (*Lepidochelys kempii*) (Ruben and Morreale 1999, NOAA 1999.) The three species of chelonid turtles remain very briefly in open ocean waters, spending most of their summer months in harbors and estuarine waters. Abundant prey resources of these nearshore productive environments result in high juvenile growth rates before their activity slows in the fall.

Five species of sea turtles have been documented in the New York Bight, although none nest in the area. The loggerhead sea turtle is federally threatened and the Kemp's ridley, leatherback turtle (*Dermochelys coriacea*), hawksbill turtle (*Eretmochelys imbricate*), and green sea turtles (*Chelonia mydas*) are federally endangered. Sea turtles occurring in nearshore waters are typically small juveniles; the most abundant is the loggerhead turtles, followed by the Kemp's ridley. The waters off Long Island are also warm enough to support green sea turtles from June through October. The leatherback turtle, which is the most commonly observed turtle from May through October, utilizes offshore areas and is not found in the estuaries or backbay areas. The hawksbill sea turtle rarely occurs in the area and is probably an anomalous visitor. Sea turtles begin arriving in New York waters in June and July and remain for several weeks, using the shallow coastal waters to forage. Kemp's ridley and loggerheads feed primarily on benthic crustaceans, and green sea turtles feed primarily on eelgrass and algae. The leatherback sea turtle remains offshore of the barrier island and commonly feeds on jellyfish and ctenophores. Sea turtles leave the area by late fall as water temperatures decrease.

Since European settlement, however, there appears to have been a drastic decline in habitat quality for sea turtles which is reflected in the decreased number of sightings reported since the early 1900's (FWS 2001). Until the 1930's Raritan Bay with its extensive eelgrass beds provided very suitable habitat for sea turtle species and DeSola (1931) reported seeing great numbers of turtles there. Shortly thereafter, however, the eelgrass beds were wiped out by wasting disease and to this day have not fully recovered (FWS 2001). This pattern of degradation may be reflected in the usage of the bay by sea turtles, which were once apparently abundant, but have since been rarely recorded.

Loggerhead Sea Turtle

Of all the sea turtles, the loggerhead is the most temperate and subtropical in its nesting habits, which makes it the best candidate for use of more northerly waters in general. Loggerhead adults have shells ranging in size from 84-101.6 cm and weigh between 68-182 kg. The shell is reddish brown and composed of horn covered bony plates. Although the precise reasons why young sea turtles enter northeastern waters are not known, it is thought that these waters provide important developmental habitat for a number of chelonid turtles (Morreale and Standora 1994). Loggerhead turtles were the most frequently sighted species of turtle during the CeTAP surveys of 1982. Most of the sightings were concentrated on the continental shelf and in estuaries from Long Island to Chesapeake Bay.

Sadove and Cardinale (1993) report that loggerheads are the earliest species to appear in New York waters and arrive as early as May. During tagging and telemetry studies conducted from 1987-1992, 337 captures of sea turtles were made and the loggerhead represented 65% of the total. Results show that sea turtles occur with regularity in New York waters from June through the first week of November. All of the turtles tagged during Morreale and Standora's study (1994) showed a steady southward movement along the coastline after leaving the inshore New York waters.

Loggerheads consume a wide variety of benthic organisms including gastropod and pelecypod mollusks, decapod crustaceans, jellyfish, sea urchins, sponges, squids, basket stars, and fishes (Nelson 1988, NMFS and FWS 1991, Morreale and Standora 1994). In Long Island waters, NY waters, crabs made up 80% of loggerhead diets.

Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle is the smallest of the sea turtles. Adults do not exceed shell lengths of 76 cm and range in weight from 36-45 kg. Kemp's ridley sea turtle populations have suffered one of the most dramatic declines in population numbers observed for any animal (FWS and NMFS 1992). Like the loggerhead, Kemp's ridleys use northeastern waters as developmental habitat, foraging throughout the summer until decreasing temperatures send them southward in the fall. Numbers in New York waters during Morreale and Standora's (1994) study represent the highest concentrations of this species outside of the Gulf of Mexico.

Morreale and Standora (1992) found Kemp's ridley turtles feeding primarily on crabs in NY waters. In their tracking studies, they determined that Kemp's ridleys are sub-surface animals that frequently swim to the bottom while diving. Analysis of stomach contents in Cape Cod Bay indicates that they are feeding on fish, sand dollars, bay scallops, and blue mussels.

Green Sea Turtle

Green sea turtles are a medium to large sized turtle with the shells of adults ranging in length from 91-110 cm and weighing between 91-136 kg. This species is primarily herbivorous and has a serrated edge on the lower jaw. It is most commonly found in tropical waters and usually do not migrate from their regular habitat except to visit nesting beaches. The major threats to green sea turtles are trawls and gillnet fisheries. In addition, extensive trade in the animals and their products still exists in some areas, and effectively wiped out the population around the Bermuda Islands.

Immature turtles go through an omnivorous stage (1-3 years) and may be feeding on different food items than the preferred vegetation consumed by adults. This may explain the use of New York waters by juveniles. Data from dietary studies in New York indicated that they were feeding primarily on algae (Burke *et al.* 1992).

A 38 cm green sea turtle captured, tagged, and released in New York was recaptured almost 1 year later only 13 km from the original capture site (Morreale and Standora 1994), suggesting that during the developmental stages, these turtles may return for a number of years before becoming an adult and taking up residence in more tropical seagrass beds. Growth rates for green turtles were higher in New York than in both Florida and Hawaii, but lower than in the Bahamas. This suggests that New York waters provide significant foraging opportunities.

Leatherback Sea Turtle

Leatherback sea turtles are the largest of the sea turtles ranging in curved carapace length from 137-183 cm and weighing from 204-696 kg. The estimated worldwide population of leatherbacks is about 115,000 adult females. CeTAP (1982) provides conservative estimates of peak average abundance at 361 (+/-181) for Mid- and North Atlantic regions of the continental shelf. In New York waters these are the primary species entangled in fishing gear and struck by boats and do not seem to suffer from the same causes of mortality as chelonid sea turtles (trawls, gill nets, and cold stunning) (Morreale and Standora 1994). Although this species is known to occur in the action area, they are only present as occasional transients.

The main component of the leatherbacks' diet consists of arctic jellyfish. It is thought that leatherbacks follow their prey north along the western Atlantic to the Gulf of Maine, Georges and Brown Banks in summer, then traveling south through the bays and sounds in the fall (Lazell 1980).

Northern Right Whale

Right whales have an exceptionally large head (28-33% of their body) and are generally broad for their length. Young of the year average 9m and adults reach lengths of up to 17m and can weigh up to 40 tons. The Northern right whale is considered the most endangered of the large whales and the North Atlantic population has been estimated at between 300 and 350 individuals. However, the most recent estimate, based on photo identification representing a nearly complete census, indicates a population size of about 395 individuals (Blaylock *et al.* 1995). The population growth rate is slow and well below the 6-7% growth rate seen in the South Atlantic population during the same period. The most recent data (1994) shows a current population growth rate estimated at 2.5% (Blaylock *et al.* 1995). It is thought that the slow recovery is due to human interaction (net entanglement, ship strikes), habitat degradation, and inbreeding.

Hamilton *et al.* (1994) report that interactions with fishing gear and boats in increasing; 27 of the animals sighted in the southeast during the winter of 1993 showed signs of previously undocumented entanglements. In addition, 3 more animals were documented as carrying lines in the fall of 1994.

Right whales found in the New York Bight are primarily transiting the area on their way to more northerly feeding and concentration in the Great South Channel, Cape Cod Bay, and Browns/Baccarro Banks. During the late winter and early spring they begin moving north along the coast past Cape Hatteras and near the Long Island coast before passing through the Great South Channel. Individuals are sighted along the south shore of Long Island and occasionally within Long Island Sound, Block Island Sound, Gardiners Bay, and south shore inlets and bays, but individuals and cow/calf pairs do not remain in the area for an extended period of time (Sadove and Cardinale 1993).

The right whale is planktivorous, feeding primarily on calanoid copepods (Wishner *et al.* 1988). Right whale distribution is generally patchy and is probably due to the patchy distribution of their preferred forage, *Calanus finmarchicus*.

Humpback Whale

Humpback whales can reach up to 18m in length and have a small, variably shaped dorsal fin, long distinctive flippers, and the fluke is deeply notched with an irregular saw-toothed edge. NMFS/Northeast Region entanglement database reports 64 records of entangled humpback whales from 1975-1992. Of 20 stranded individuals examined for cause of death, Wiley (1995) reports that 6 had major injuries attributable to ship strikes and 5 of the 6 were indicative of entanglement in fishing gear.

The distribution of humpback whales in the northwestern Atlantic is changeable, and probably a response to changing distributions of preferred food sources. Both humpback and finback whales have been confirmed in the Hudson. However, these records cluster in spring and early summer and probably represent young or dispersing individuals, transient in the area. Historic records do not show the New York Bight to be a high use foraging area for large cetaceans(NMFS 1995, 2003).

Sadove and Cardinale (1993) report that humpback whales aggregate in New York in various years, but with no regularity of occurrence. They have been sighted in Long Island Sound, Gardiners Bay, and Block Island Sound, and some individuals have remained in these areas for more than a week. They are present in the greatest numbers in June through September. For the most part, humpbacks are in transit through the area on their northward migration to summering areas in the Gulf of Maine.

Humpback whales are primarily piscivorous and seem to select prey opportunistically. Humpback whales have not used New York waters historically as a feeding area, but are concentrated in Gulf of Maine waters most years opportunistically exploiting prey species such as sand lance, herring, and mackerel.

Finback Whale

Finback whales are the second largest whale, reaching lengths of up to 24m. They are characterized by a white “chevron” along their right side that may play a role in their feeding strategy. They occupy both deep and shallow waters and are probably the most abundant large cetacean in New York waters and are present year round. They are most abundant in New York waters in spring and summer, but do have some presence during the winter months.

Finback whales feed on a variety of schooling fish, euphasids, and copepods both at the surface and at depth. They have often been observed turning on their side when opening their mouths and circling through or around a school of fish with their right side facing downward. A major area of feeding was sighted directly east of Montauk Point during spring and summer. The drift patterns of their preferred forage explain the concentration of fin whales east of Montauk Point in summer.

Shoreline Species and Habitat

These resources are discussed because these areas provide food for both piping plover and least tern as well sea turtles and some marine mammals. Because these resources may potentially be impacted by the proposed projects, it is important to discuss how these impacts may, in turn, indirectly affect T & E species in the action area.

Intertidal Zone Habitat

The upper marine intertidal zone is primarily barren; however, more biological activity is present in comparison to the upper beach. Organic inputs are derived primarily from the ocean in the form of beach wrack, which is composed of drying seaweed, tidal marsh plant debris, decaying marine animals, and miscellaneous debris that washed up and deposited on the beach. The beach wrack provides a cooler, moist microhabitat suitable to crustaceans such as the amphipods: *Orchestia* spp. and *Talorchestia* spp., which are also known as beach fleas. Beach fleas are important prey to ghost crabs. Various foraging birds and some mammals are attracted to the beach fleas, ghost crabs, carrion and plant parts that are commonly found in beach wrack (ACOE 2002).

Benthos of Intertidal and Subtidal Zone

The ACOE, through its Biological Monitoring Program, analyzed data collected for a restoration project to the south of Sandy Hook between Asbury Park and the Manasquan River. The intertidal benthos, prior to placement of fill, were dominated by three taxa: Rhynchocoela, the spionid polychaete, *Scolelepis squamata*, and Oligochaeta. Rhynchocoelas were the most abundant organism (66%), Scolelepis (16%), and Oligochaeta (14%) of total abundance (ACOE 1998). Eddings *et al.* (1990) conducted limited sampling on the northern beaches of Sandy Hook, but did not analyze the core samples by prey base type. Local sampling methods were not comparable to those of the BMP of the ACOE, and no data exist on benthic fauna of the Critical Zone area. Due to the proximity of sandy Hook to the ACOE sampling areas, the faunal is expected to be quite similar.

Macroinvertebrate populations are subject to significant seasonal variations. However, the ACOE study identified high densities at specific sites and times rather than a consistent difference between areas, stations, or seasons. In terms of impacts to the fauna in the swash zone, there was no statistical difference in abundance, diversity, composition, or total biomass between samples collected before and after nourishment in their adjacent study areas (ACOE 1999a, 1999b, 2001a). The ACOE BMP found that complete recovery of the intertidal infaunal assemblage occurred between two months and six and one half months. Because the area of impact is relatively small in the proposed pipeline project, recolonization is expected to occur much more rapidly than in the more extensive adjacent beach fill projects and is expected to be recovered within several tide cycles or two days.

Benthic invertebrates are an important link in the aquatic food chain and provide a food source for a variety of bottom feeding fish species. The organisms inhabiting the beach intertidal zone have evolved special locomotory, respiratory, and morphological adaptations, which enable them to survive in this extreme habitat. Organisms of this zone are agile, mobile, and capable of resisting long periods of environmental stress. Most are excellent and rapid burrowers. Frequent inundation of water provides suitable habitat for benthic infauna; however, there may be paucity in numbers of species.

Factors such as hydrography, sediment type, depth, temperature, as well as inter/intra specific population dynamics influence species dominance in benthic communities. Intertidal benthic organisms tend to have a high rate of reproduction and a short (1 to 2 years) life span (Hurme and Pullen 1988). Generally, coarse sandy sediments are inhabited by filter feeders and areas of soft silt or mud are more utilized by deposit feeders, however, considerable overlap can occur.

ACOE (2002) reports the results of October sampling in the Ocean City area. The most dominant taxa found in both of these zones was the small common surf-zone clam (*Donax variabilis*), the highly mobile haustorid amphipod (*Amphiporeia virginiana*), the mole crab (*Emerita talpoida*), and the mobile polychaete *Scolelepis squamata*. Comparisons were made in this study between the sand-filled area of Ocean City where the currently authorized Federal beach replenishment project is located and remaining undisturbed areas throughout the study area. This study found that the mean number of taxa, total abundance, and total biomass were higher in the sand-filled area samples of the intertidal zone, however, total biomass was significantly lower in the sand-filled area of the nearshore subtidal zone.

Man-made structures such as seawalls, jetties, and groins provide habitats for aquatic and avian species. Benthic macroinvertebrates such as barnacles (*Balanus balanoides*), polychaetes, molluscs (*Donax spp.*), small crustaceans such as, mysid shrimp (*Heteromysis formosa*), amphipods (*Gammarus spp.*), and uropods (*Idotea baltica*), reside on and around these structures. The blue mussel, *Mytilus edulis*, is a dominant member of this community. Sea gulls and other water birds use them for perching, loafing, roosting, and foraging sites.

Interstitial species (meiofauna) are present feeding among the sand grains for bacteria and unicellular algae, which are important in the beach food chain. Meiofauna are generally < 0.5 mm in size and are either juveniles of larger macrofauna or exist as meiofauna during their entire life cycle. Some common meiofauna include Rotifera, Gastrotricha, Kinorhyncha, Nematoda, Archiannelida, Tardigrada, Copepoda, Ostracoda, Mystacocarida, Halacarida, and many groups of Turbellaria, Oligochaeta, and some Polychaeta.

Nearshore and Offshore Zone

The nearshore coastal zone generally extends seaward from the subtidal zone to beyond the breaker zone (ACOE 2000). This zone is characterized by intense wave energies that displace and transport coastal sediments. The offshore zone generally lies beyond the breakers and is a flat zone of variable width extending to the seaward edge of the Continental Shelf. Hurme and Pullen (1988) describe the nearshore zone as an indefinite area that includes parts of the surf and offshore areas affected by nearshore currents, as their boundaries may vary depending on relative depths and wave heights.

Benthos of Nearshore and Offshore Zones

New Jersey Atlantic nearshore waters provide a dynamic environment heavily influenced by the tidal flows and long-shore currents (ACOE 2000). The nearshore and offshore waters of the New Jersey Coast contain a wide assemblage of invertebrate species inhabiting the benthic substrate and open water. Invertebrate Phyla existing along the coast are represented by Cnidaria (corals, anemones, and jellyfish), Annelida (Polychaetes, Oligochaetes), Platyhelminthes (flatworms), Nemertinea (ribbon worms), Nematoda (roundworms), Bryozoa, Mollusca (chitons, clams, mussels, etc.), Echinodermata (sea urchins, sea cucumbers, sand dollars, starfish), Arthropoda (Crustaceans), and the Urochordata (tunicates).

Benthic investigations at several potential sand borrow sites offshore of the Ocean City area were dominated by polychaete worms, while the Corson Inlet area was dominated by the bivalve, *Donax fossor*. Amphipod crustaceans also contributed substantially to the faunal composition, but to a lesser extent in the offshore areas.

Larger benthic macroinvertebrates sampled in the Ocean City Study were obtained from commercial surfclam dredges in the same areas. The most frequently collected invertebrates included: surfclam, knobbed whelk (*Buscyon carica*), channel whelk (*Buscyon canaliculatum*), horseshoe crab (*Limulus polyphemus*), moon snail (*Polinices* spp., *Lunatia* spp.), spider crab (*Libinia emarginata*), and hermit crab (*Pagarus* spp.) and starfish (Echinodermata).

PROJECT PURPOSE AND NEED

The New Jersey coastline including Sandy Hook has a long history of shoreline stabilization (Gorman 1988, Gares 1981). Shoreline stabilization efforts immediately to the south of Sandy Hook have significantly altered the NPS shoreline since 1900 and created a sand deficit along its southern Critical Zone (Allen 1981, Phillips *et al.* 1984, Slezak *et al.* 1984). Jetties and groins, built over the decades in Monmouth Beach and Sea Bright, and the sea wall near the southern boundary of the Park have prevented sand from reaching Sandy Hook's southern beaches (Psuty and Namikas 1991). These beach protection structures, designed to prevent erosion, have actually interfered with the northern littoral drift of sand along the New Jersey shoreline. Although some sand is still deposited at the Critical Zone, the amount is insufficient to counter losses due to erosion. As a result, the sand deficit at the southern end of Sandy Hook continues to grow.

Continued erosion on this southern portion of Sandy Hook has reduced recreational bathing beaches and jeopardizes newly constructed beach facilities and public access. Furthermore, without an adequate sand barrier in place, access beyond the Critical Zone will eventually be denied due to inevitable breaching of the spit. Important historic and cultural resources would be threatened as well as continuing public access to these resources.

The Critical Zone has been nourished several times since the establishment of Gateway NRA in 1972. Projects in the late 70's utilized sand that was trucked in from other areas. In 1981 and 1982, severe storms overwashed Hartshorne Drive at the South Beach area. The beach was nourished from 1982 to 1984, restoring the beach cross-section to the 1954 contour. Approximately 3,000,000 cy (2,293,800 cubic meters) of sand were placed at the nourishment site at that time. In 1989 and 1990, the site was nourished with approximately 2,600,000 cy (1,987,960 cubic meters) of sand from Sandy Hook Channel.

A sheet pile bulkhead was also installed along the east side of Hartshorne Drive to prevent a breach. Subsequent erosion removed the protective dune and a major portion of the recreation beach. The National Park Service has spent approximately $32 million on beach replenishment to maintain the shoreline and vehicle access to Sandy Hook.

Between late 1996 and early 1997, a combination of fierce storms and unusually high tides resulted in breaches of the Park's main access road at the Critical Zone, causing temporary road closures, damage to newly constructed beach facilities and parking lots, and severe erosion of recreational bathing beaches. As a result, the National Park Service undertook an emergency sand replenishment project in January 1997 to provide immediate protection to the road and beach facilities against future storms. Approximately 60,000 cy of sand were transported by truck from the Gunnison Beach area, at the northern end of Sandy Hook, to the Critical Zone, located one mile north of the Park entrance between January and March. Nearly 90% of the sand that was placed during the winter months was eroded by additional storms and high tides between April and June 1997, leaving the Critical Zone and Parking lots at Area D subject to overwash during periods of high tide. On six different occasions during 1997, mainland access to Sandy Hook was severed due to inundation of Hartshorne Drive, the only access route to and from the peninsula.

The most recent incident occurred on October 19-20, 1997. Replenishment in 1997 - 1998 involved the placement of approximately 287,500 cy of sand to provide immediate protection of the Park road and beach facilities. Sand was obtained from the State of New Jersey/ACOE offshore borrow site (ACOE 1989). Most recently, in November 2002 an additional 253,000 cy of sand, at a cost of $1.9 million from the NPS Fee Demonstration Fund was placed in the critical zone through an amendment to the US ACOE contract beach replenishment work in northern Monmouth County. However, NPS has been informed by the ACOE that sand sources are now a limiting factor for replenishment projects in the area. Due to budgetary and sand source supply constraints, it is anticipated that future quantities of sand would need to be obtained from Gunnison Beach at the northern end of Sandy Hook.

Based on past performance models, approximately 1.5 million cy of sand is needed for replenishment at the Critical Zone every 5-7 years, or 250,000 cy/yr, to counter beach erosion. Previous replenishment projects occurred in 1977, 1982-83, 1989-90, and more recently, during the winters of 1996-97, 1997-98, and one is planned for 2001-02. However, the recent large-scale beach replenishment projects immediately south of Sandy Hook at Sea Bright by the ACOE have increased sediment availability in the Critical Zone. The amount of sand needed to maintain a stable system and prevent sand deficit is now estimated to be less than half of original projections (100,000 cy). These recent long-term (50 yr) ACOE NJ coastline fill projects (ACOE 1989, 1993) have significantly altered the nearshore sand budget, providing more sand for transport around and past the Seawall into the Sandy Hook system. An estimated 200,000-250,000 cy now move through the Sandy Hook system on an annual basis, and an estimate of 55,000 cy is now considered necessary to maintain an equilibrium state as well as the existing character of the Critical Zone (Psuty 2001- 2003).

ALTERNATIVES

Since the 1970's, a wide range of alternatives has been considered for maintaining public access and recreational opportunities at Sandy Hook. These alternatives have been analyzed by interdisciplinary teams of experts resulting in a variety of decision documents. A summary of these documents and proposed recommendations are outlined below.

Assessment of Long Range Alternatives for the Reestablishment and Maintenance of the South Beach Area, Sandy Hook Unit, Gateway National Recreation Area, New York - New Jersey (1978)

Applied Science Discussion of Management Alternatives (Nordstrom, *et al.*, 1982)

Assessment of Alternatives for Long Term Management of Critical Zone Erosion, Sandy Hook Unit, Gateway National Recreation Area (1988)

Assessment of Alternatives for Long-term Management of Critical Zone Erosion, Sandy Hook Unit, Gateway National Recreation Area (1994)

Value Analysis Study for Providing Access and Beach Improvements at the "Critical Zone", Sandy Hook Unit, Gateway National Recreation Area (1995)

Value Analysis Study for Sandy Hook Beach Replenishment, Gateway National Recreation Area (1997a)

Value Analysis Study for Sandy Hook Beach Replenishment, Gateway National Recreation Area (2003)

In August 2003, the National Park Service conducted its most recent value analysis study to provide and document the best management strategy and most cost-effective solution to solving the problems at the Critical Zone while meeting the legislative mandates of the Park. This study built upon the results of the 1997 and 1995 value analysis studies and explored a range of alternatives for beach sand replenishment. Recommendations were made in three areas: (1) options and methods for beach sand replenishment, (2) methods to slow the loss of beach sand, and (3) strategies to ensure long-term maintenance of the Critical Zone.

The recommended solution proposed by the interdisciplinary study team was to provide full beach re-nourishment, coupled with construction of a slurry pipeline that would provide the infrastructure necessary for cyclic sand replenishment. It was believed that this combination would guarantee long-term access to the Sandy Hook peninsula without requiring construction of a causeway as was recommended in the 1995 study. No structural methods were recommended due to the known failure of many of these methods, as well as the unproven history of others.

Previous assessments completed over the past 20 years (outlined above) analyzed a variety of alternatives for dealing with ongoing erosion at the Critical Zone. These assessments corroborate the findings of previous studies as well as decades of coastal geomorphologic research conducted on the Sandy Hook peninsula. Each confirms that beach replenishment offers the best, most cost-effective solution for providing access and maintaining recreational opportunities at Sandy Hook.

The following discussion describes the range of alternatives considered for replenishing sand at the Critical Zone and where applicable, the reasons for rejecting an alternative from further consideration. A preferred alternative has been identified based upon natural and cultural resource concerns, budgetary constraints, and associated impacts on visitor use and Park operations, as well as the ability to satisfy Park management objectives. The primary difference among alternatives is in the location of the sand source, method of transport, and frequency and volumes of beach replenishment.

ALTERNATIVES CONSIDERED BUT REJECTED

All of the following actions were initially considered as potential solutions for dealing with the erosion problem at the Critical Zone. However, each was later dismissed from further analysis due to economic considerations, lack of a dependable sand source, or unacceptable impacts on Park resources, visitor use, and NPS operations.

Truck Transport-Obtain Sand from Gunnison Beach and Transport to Critical Zone via Truck.

During the winter of 1997, approximately 60,000 cy of sand was trucked from Gunnison Beach to the Critical Zone over a 45-day period. To move this quantity of sand required trucks and heavy machinery to operate for two shifts a day, six to seven days per week. During that time, two lanes of Hartshorne Drive were closed from Area C to Atlantic Drive, and Atlantic Drive was closed from Hartshorne Drive to Gunnison Road. Based on this experience, the National Park Service believes that excavating sand from Gunnison bathing beach (between the restricted plover protection areas) and then trucking it to the Critical Zone would be costly, inefficient, and would adversely affect visitor use and Park operations. Impacts to the beach from 45 days of intensive heavy equipment use are considered to be least desirable in terms of potential disruption of cultural and natural resources.

Develop New Off-Shore Sand Source.

This option was dismissed from further consideration due to the uncertainty associated with locating a suitable off-shore borrow source, not to mention the cost involved, testing required, and permit considerations associated with developing such a site. Recent discussions with the ACOE indicate that there is a high demand for alternate sand sources and that these sources, including the Sandy Hook Channel Dredge, would not be available to NPS in view of the many ongoing replenishment projects in need of additional sand. Nonetheless, NPS will continue to inquire of ACOE for the future, but recent inquiries have been denied. Instead, the ACOE has recommended that NPS use its own sand that is accreting on northern Sandy Hook.

Use Approved Off-Shore Borrow Site-Take Advantage of State Dredging Program and Long Term ACOE Adjacent Replenishment Projects.

To eliminate mobilization and demobilization costs associated with dredging operations (which run approximately $1,000,000 per operation), the National Park Service considered tagging onto the state of New Jersey's offshore dredging program. However, this idea was also dismissed from further consideration since the state had already denied earlier requests made by the National Park Service and because there is no guarantee that the State's dredging schedule could always accommodate the Park's needs.

Additionally, NPS considered piggy-backing on ACOE's Beach Replenishment Project at the adjacent town of Sea Bright. Since the ACOE Sea Bright Beach Replenishment Project has been approved for 50 years, and is scheduled for replenishment at Sea Bright every 5-7 years, it was thought that NPS could coordinate with ACOE which would increase the sand volume at Sea Bright by the amount needed at Sandy Hook. It was also hoped that the deposition area might also be extended around the Northern terminus of the seawall to the Critical Zone and Parking lot areas to address Sandy Hook's sand deficit. However, the EIS project scope and approved project did not include this option, and NPS has approached the ACOE for such a coordinated project with no success. Additionally, NPS would then be subject to the schedule of this project without the flexibility of addressing erosion needs on a timelier basis.

Construct Groins, Seawalls, and Breakwaters to Slow the Loss of Sand at the Critical Zone.

Previous studies examined the potential for beach protective measures such as groins, seawalls, onshore and offshore breakwaters, and other built structures to slow the loss of sand at the Critical Zone. Because structural solutions would merely displace the locus of erosion by shifting the Critical Zone northward, the National Park Service does not believe that such measures offer viable options for dealing with ongoing erosion. The construction of additional man-made structures would only complicate the sand transport system and take it even further from its natural state. NPS policy and desire is to maintain as natural state of shoreline equilibrium and sand transport as possible in view of historic and current artificial perturbations.

Modify Groins at the Southern End of Sandy Hook to Increase Sand Deposition at the Critical Zone.

Notching or shortening the existing groin field at the southern end of Sandy Hook may encourage more sand to migrate north, increasing the likelihood that some of the 17 million cy of sand being emplaced by the ACOE as part of the Sea Bright project reaches the Critical Zone. However, without accompanying beach nourishment, this action would only delay breaching of the spit since natural deposition rates would not overcome the sand deficit. More relevantly, groin compartments are now full of sand, and have been rendered dysfunctional. This is allowing sand to pass the existing groin structures without being impeded, as they are submerged under the sand. Since these groins are covered with sand, and are expected to continue to be submerged by the sand from the ACOE Sea Bright fill for 50 years, notching of the groins now would serve no function.

If, however, these groins become exposed in the future, due to an increased sand deficit, NPS will reevaluate the effectiveness of this action.

However, once the groins are removed or notched, the beach width will retreat as sand migrates north and will continue to retreat until it reaches the notch in the groin or the seawall. Once this occurs, sand will no longer be transported into the Critical Zone. Additionally, existing recreational beaches and beach habitat used by piping plover, least tern and seabeach amaranth will be greatly reduced or lost. Therefore, this alternative is considered ineffective as a stand alone action.

Obtain Sand for Beach Replenishment from Non-T & E Species Beaches at Sandy Hook.

In the past, piping plovers have nested at 6 different locations along the Sandy Hook peninsula, including portions of the Critical Zone, Gunnison Beach, North and Coast guard Beaches, and Fee and Hidden Beaches (Figure 3). Seabeach amaranth has recently colonized the Critical Zone and south Gunnison beach and northeastern beach tiger beetles remain on North Beach. Obtaining sand for beach replenishment from non-T & E species beaches at Sandy Hook is not feasible because there are no other accreting sites outside T & E species in their restricted protected areas of occurrence. The accreting beaches at the north end of the Hook (North and Coast Guard Beaches) are large and potentially suitable as sand sources, but are not being considered due to the fact that they support T & E species and are therefore restricted protection areas. The only unrestricted accreting beach is the Gunnison Bathing beach where the borrow site is proposed for the slurry pipeline.

Permit Breach and Provide Ferry Transport.

Under this alternative, the NPS would have permitted breach of the Critical Zone. Subsequent to the breach, visitors, employees, and residents would have been transported by ferry to northern areas of the Park from remote Parking areas south of the breach. This alternative was rejected as a viable solution to the public access due to high costs; severe access restrictions to visitors, employees, and residents; safety considerations; low sustainability; and exposure of the Highlands waterfront. However, NPS is now exploring this as a project for a number of reasons, and ferry service is likely to be provided in the future, although not at a level commensurate with NPS Gateway public use mission or a replacement for road access.

Construct Causeway.

Under this alternative, the NPS would have constructed an elevated causeway through the Critical Zone within the existing alignment of Hartshorne Drive. The road would have been approximately one mile long and would have been elevated approximately 10 feet on fill material; the sides of the causeway would have been armored with rip-rap. This alternative was rejected from further consideration due to high costs, extensive loss of wetlands and disruption of natural communities, and low sustainability. Also, due to the highly dynamic nature of the Critical Zone, it is difficult to predict the stability, longevity and movements of the shoreline, or any potential inlet movement. Construction design and maintenance of such an infrastructure would be costly in order to compensate for such a highly dynamic shoreline (minimum estimated $50-100 million initial construction). Construction of such an infrastructure would require significant maintenance and perpetuate the need for further and more costly and continuing stabilization efforts.

Lagoon construction.

This alternative includes the use of a small portable cutterhead dredge; with a 400 HP dredge pump and a 12”ø discharge pipeline operating from within a lagoon built into Gunnison Beach, which would hydraulically pump sand through a discharge pipeline from Gunnison Beach to the Critical Zone. The dredge measures approximately 40 ft long by 15 ft wide.

This alternative includes the following steps: (1) transport the dredge, in basically two pieces, on a flatbed truck to the site where it would be quickly assembled for operation, (2) with earth excavation equipment, dig out a lagoon area from which the dredge would operate, approximately 100 ft long by 50 ft wide with a bottom depth of approximately 4 ft below mean low water, set back from the beach’s high water line, (3) continue the excavation with a channel from the lagoon to the ocean including a sand weir across the channel that would allow a controlled water supply to feed the lagoon for proper, continuous dredge operating depths, (4) with the dredge operating from the lagoon, earth moving equipment would move sand from the nearby accreted beach area and dump the sand into the end of the lagoon where the dredge intake is located, in order to provide a continuous source of sand supply, (5) the dredge would pump the sand to the Critical Zone, and (6) the lagoon would be backfilled after the pumping is completed.

It is noted that since the dredge can operate from within the lagoon, away from the surf zone and in calm lagoon water, dredging during the harsh winter months would not be a problem except during heavy wind or storm conditions.

The total first cost for Plans are $2,500,000 and $1,700,000, respectively with the annual O & M costs at $800,000 and $1,700,000, respectively. These plans were deleted mainly due to high O & M costs and the cumbersome nature of sand retrieval with bulldozers and sand transport with trucks. There were also significant environmental and visitor use concerns with building a lagoon into the beach.

Permanent Pumphouse on Gunnison.

This alternative includes the construction of a sand slurry pump station and discharge sand slurry pipeline to the Critical Zone. The pump station would be equipped with a 400 HP submersible pump and a jet water pump to draw water from the ocean through a flexible, removable pipeline (10”ø). This pump would divert the ocean water to two ports at the opposite sides of the slurry mixing chamber and utilize a baffle at each port to enhance circulation in the slurry mixing chamber and avoid turbulence. This water line would also supply water needed for the operation of the booster pumps via a 2”ø pipeline paralleling the 10”ø slurry pipeline.

Sand would be delivered to the pump station by truck where the sand would be dumped into a hopper adjacent to the mixing chamber. Slide gates built into the wall adjoining the hopper and mixing chamber can be raised or lowered, from the control panel in the pump station, to vary the slurry mix for more efficient sand transport.

The pump station can be located on Gunnison Beach. This will require a permanent discharge slurry pipeline from the pump station to the Critical Zone, for cost effectiveness, vs. the mobilization and demobilization of a temporary discharge pipeline, every year. Earth moving equipment such as 2 loaders would load sand at Gunnison Beach, onto 2-20 cy dump trailers, or equivalent, which would then be transported to the hopper at the pump station.

It is noted that to reduce grading costs at the Critical Zone, three short spur pipe segments with valves feeding off the main pipeline and discharging to the beach at approximately 500 to 1,500 ft intervals would be included. This would supply sand along the Critical Zone to minimize the sand grading effort.

The first cost of this alternative is approximately $2,200,000 with annual O & M costs of $800,000. This plan was deleted mainly due to high annual O & M costs and the cumbersome and environmentally intrusive nature of the sand transport operation with trucks and sand retrieval with bulldozers.

Stop-Gap.

Respond to Critical Situations as they Arise Using Short-term, Stop-Gap Measures; Rebuild Full Beach Profile on 5-7 Year Interval (Continuation of Existing Conditions)

Existing management practices are two-fold and involve responding to critical situations as they arise, along with rebuilding the shoreline to the full beach profile on a regular interval. This approach to erosion control at the Critical Zone represents crisis management and would be a continuation of existing conditions. Park management would continue to respond to critical situations as they arise with a series of short-term, stop-gap measures such as the use of sand bags to protect the road and trucking of sand to replenish eroded beaches. In the past, the sand source for such measures has been Gunnison Beach at the northern end of Sandy Hook (NPS 1998).

In addition to implementing emergency stop-gap measures when needed, the National Park Service would continue to replenish the Critical Zone with approximately 1.5 million cy of sand every 5-7 years to restore the beach to the 1998 shoreline profile and counter beach erosion. Currently the National Park Service has approval to remove this amount of sand from the State of New Jersey/U.S. Army Corps of Engineers Sea Bright 89 borrow site, located approximately 1.8 miles offshore from Sandy Hook. This is the same borrow site currently being used by the Corps of Engineers for the Barnegat to Sea Bright beach nourishment project. Sand would be extracted from the borrow site using a hopper dredge, pumped out via a mooring platform, and transported directly to the beach by a temporary, floating pipeline. Once deposited on the beach, the sand would be graded by onshore earth-moving equipment. To date, the National Park Service has removed approximately 300,000 cy of sand from the Sea Bright borrow site. Since the National Park Service is only authorized to remove 2.5 million cy from this site, the

National Park Service would either need to renegotiate with the Corps of Engineers to remove additional quantities of sand from the Sea Bright borrow site, or other sand sources would have to be identified to meet future needs.

Continuing discussions with ACOE confirm collective concerns about future sand availability and source sustainability for all replenishment projects in the area.

According to the Army Corps of Engineers, mobilization/demobilization costs for dredging operations run approximately $1,000,000, and the cost of pumping sand is currently about $4.00 per cubic yard. The total estimated cost of pumping sand from this offshore source is approximately $2,500,000 per pumping operation. This plan was deleted mainly due to high O & M costs.

Stop-Gap with Pipeline.

Obtain Sand on an As-Needed Basis from an Approved Off-Shore Borrow Site and Transport to Critical Zone via an Underwater Marine Pipeline.

This alternative would use the same sand source as described for Alternative B as well as a similar method of transport; the major difference between the two alternatives is in the location of the pipeline and degree of permanency. In this alternative, an underwater pipeline would be constructed to transport sand from the State of New Jersey/U.S. Army Corps of Engineers Sea Bright 89 borrow site to the Critical Zone. Sand would be extracted from the borrow site using a hopper dredge, pumped out via a mooring platform, and transported directly to the beach by an underwater pipeline anchored to the ocean floor. Once deposited on the beach, the sand would be graded by onshore earth-moving equipment.

In addition to the estimated costs presented in Alternative B ($2,500,000 to cover equipment mobilization and cost of sand), costs associated with actual pipeline construction would be approximately $300,000. This plan was deleted mainly due to high O & M costs.

ALTERNATIVES NOW CONSIDERED

Alternative A: No Action

Under the no-action alternative, the National Park Service would make no attempt to control ongoing beach erosion. As the sand deficit in the Critical Zone continues to build, access would be gradually lost to most of Sandy Hook due to irreparable damage to Hartshorne Drive. Within a few years the spit would be breached and an inlet would form, causing Sandy Hook to become an island. Tidal flow through the uncontrolled inlet would cause accelerated erosion on both ocean and bayside beaches resulting in a loss of recreational bathing beaches and millions of dollars of beach facilities. Without an adequate sand barrier Park closures would occur, adversely impacting the millions of annual visitors as well as the numerous federal and state agencies, schools, private organizations and approximately 1,000 employees working on Sandy Hook. Access to the cultural and historical resources on Ft. Hancock would be significantly curtailed, limiting financial options for their physical maintenance. Other forms of access to the island would need to be pursued such as a ferry service or causeway.

If an inlet were to form, the ephemeral nature of shoreline dynamics makes it difficult to predict its longevity and morphology. Construction of any new road or ferry terminal would need to consider the highly dynamic shoreline changes, including the probabilities of inlet migration and/ or closure and attachment to the mainland at some future time. Inlet formation would create an island effect for all inhabitants and would restrict flow of human access and services as well as sand transport to the rest of Sandy Hook to maintain existing beaches and shoreline.

Creation of a new inlet could provide additional beaches suitable for plovers and other beach dependent species, but it is unclear whether the total shoreline of Sandy Hook would gain or lose suitable habitat due to the changes in sand transport caused by the new inlet. It is predicted that new inlet beaches with potential for overwash and back flat foraging habitat would be inhabited by piping plovers as in Westhampton (Houghton *et al.* 1995-2000). It is also predicted, however, that erosion and accretion rates along all of Sandy Hook would be affected by the resulting sand deficit. Prime northern nesting beach habitat may be affected by altered sand transport conditions along Sandy Hook.

Alternative B: Action Alternative

Obtain sand on a cyclic maintenance schedule from Gunnison Beach (accreting northern end of Sandy Hook) and Transport to Critical Zone via a Sand Slurry Pipeline.

The National Park Service proposes a sustainable solution of cyclic beach replenishment to best simulate and maintain shoreline equilibrium conditions, minimize beach impacts, and provide protection for NPS access roads, beach facilities and public bathing beaches. This action builds on previous studies that support sand recycling along the Sandy Hook peninsula (NPS 1988, 1994, 1997a). A permanent underground pipeline, approximately three miles (15,000 feet) in length, would be installed along the peninsula to provide the infrastructure necessary to periodically replenish sand to the Critical Zone with sand from accreting portions of Gunnison Beach at the northern portion of Sandy Hook. Only that amount of sand that accretes in a year’s time (up to 100,000 cy) would be recycled back to the southern beaches of the Park.

Once the full (1998) beach profile is reestablished at the Critical Zone (winter 2001-2 interim fill project), the most efficient and cost-effective maintenance schedule for beach replenishment would involve placement of up to 100,000 cy of sand to be pumped on an annual basis, as needed. This pumping schedule is based on a rough, preliminary cost estimate that modeled a three-year cycle (NPS 1997a). The preferred pumping schedule of up to 100,000 cy on a yearly basis would allow for complete restoration of the full beach profile and would not destroy the character of the eroding or accreting beaches, including the protective dunes, or cause damage to existing facilities. Replenishment of the beach with smaller quantities of sand on a more regular basis would also more closely mimic the amount of sand transported through natural littoral drift.

The 2003 Value Analysis and extensive ACOE New York and Philadelphia District Design Plans resulted in one action alternative with 2 options for sand removal. One advantage of this alternative is that the sand retrieval can be accomplished from anywhere along the shoreline at Gunnison Beach within a 3,000 ft range. Both options include two basic systems with common elements as follows: (1) a sand transport system consisting of a permanent buried sand slurry pipeline of 15,100 ft interconnecting 3 booster pump stations, from Gunnison Beach to the Critical Zone, and (2) a mobile sand retrieval excavation system at Gunnison Beach consisting of: (a) a crawler crane based excavator, (b) water intake jet pump for the sand slurry and sealwater for the booster pump operation or a well pump for sealwater for the booster pump near the crane, (c) mobile booster pump on sleds near the crane, (d) up to 3,000 ft of above ground temporary slurry pipeline, (e) a mobile control house on sleds, (f) a mobile collection tank on sleds, and (g) a mobile booster pump on sleds near the tank with above ground discharge pipe that connects to a concrete slab anchoring the start of the permanent buried slurry pipeline. It is noted that all the equipment for the mobile sand retrieval excavation system can be rented, but based on significantly lower life cycle costs and difficulty in finding conveniently located vendors, except for the crawler crane, it is recommended to buy and store the mobile equipment. The cost estimate is based on the sand transport system, permanently installed, as initial construction cost and the mobile, sporadically mobilized sand retrieval excavation system, as operational cost. The total first cost for Option 1 is $1,831,500 with an annualized operational cost (excluding sealwater costs) of $380,400. The total first cost for Option 2 is also $1,831,500 with an annualized operational cost (excluding sealwater costs) of $384,400.

ALTERNATIVE B: Action Alternative: SLURRY PIPELINE

Sand Transport System.

The sand transport system from Gunnison Beach to the Critical Zone includes 15,100 lf of 10” inner diameter HDPE pipe buried with an estimated 2 ft of earth cover for the sand slurry pipeline previously developed for the NPS. The alignment basically begins near the landward side of the dune at Gunnison Beach, proceeds to and advances along an area adjacent to Atlantic Ave. and then runs adjacent to Hartshorne Drive to the beach at a point midway through the Critical Zone. Three discharge ports with valves from the main pipeline will be included to minimize the need for grading the sand arriving at the Critical Zone, one at the terminus, one 1100 feet and one 3000 feet from the terminus.

The three booster pumps are located near Hartshorne Drive or Atlantic Ave. and are diesel-powered, 420 horsepower pumps spaced at locations 2,850 ft 7,350 ft and 11,910 ft from the end of the slurry pipeline at the Critical Zone. Diesel power is more cost effective than electric power for the booster pumps due to the high cost of electricity for a relatively high electrical power requirement over a short duration. In addition, electric power outages would pose a problem. Even though the initial cost of the diesel powered pump is higher than the electrically-driven pump, the life cycle cost of the booster pump powered by electricity would far exceed the cost of the diesel powered pump. The spacing of the booster pumps can be varied up to 1,000 ft in either direction, for better location, without effecting performance. The booster pumps would be portable and mounted on trailers or skids that would be placed on concrete pads measuring approximately 15’ X 20’. The booster pumps would be removed when not in use. The sealwater for the operation of the booster pumps will come from water lines servicing NPS facilities, however, this will require approximately 30,000 gallons of water per day including a fourth booster pump at the collection tank of the sand retrieval system. Sealwater could also be obtained from the ocean if necessary. Sealwater piping would run in the same trench as the slurry pipe. Water would be bled from the system after each transport operation to preclude pipe damage (NPS 2003).

Sand Retrieval Excavation System.

Option 1: Sand removal with crane and clamshell bucket. The sand retrieval excavation system that ties into the sand transport system, as described above, is completely mobile. All of the features of this system are sled or crawler mounted and are intended to be mobilized at the start of the sand transport operation of roughly 3 months duration and demobilized at the end of the 3 months of operation. The sand excavator consists of a crawler mounted crane with an approximate 200 ft long boom equipped with a 10 cy clamshell bucket that will excavate the sand in the surf zone, swing the boom and deposit the sand in a 100 cy hopper.

The bottom of the hopper is equipped with a tank feed jet pump that facilitates hydration of the sand, producing the slurry that is drawn through an adjacent mobile booster pump. The source of the water for the slurry is the ocean that is drawn into the system through a 420 HP jetwater pump. The intake hose for this pump is intended to be floating just offshore, covered with a 4-6 inch metal mesh screen and attached to a buoy. This will eliminate unintended sand in the system as well as intake of marine life. It is noted that the sealwater for this booster pump can come from a vertical well pump or fed from the ocean intake.

From the mobile booster pump, the slurry is transported through up to approximately 3,000 ft of temporary above ground 10” diameter HDPE pipe to the mobile collection tank that is roughly 10 ft in diameter and 10 ft high. The collection tank is needed to prevent clogging of the system from the hopper over the 3,000 ft of pipe. Air can be sucked into the line from the hopper or surges in sand supply can clog the pipe and over the long, 3,000-foot transport distance, can cause cavitation of the booster pumps. A mobile control house of corrugated metal is located near the tank. From this control house the slurry flow is monitored and booster pump speeds are controlled. The slurry is drawn from the collection tank by a mobile 420 HP booster pump which discharges through a 10" diameter HDPE pipe above ground to the concrete pad anchoring the beginning of the 10" diameter buried HDPE pipeline and transport system, as described above.

Option 2: Eductor sand removal--Preferred. The sand retrieval excavation system that ties into the sand transport system, as described above, is completely mobile. All of the features of this system are sled or crawler mounted and are intended to be mobilized at the start of the sand transport operation of roughly 3 months duration and demobilized at the end of the 3 months of operation. The sand excavator consists of a crawler mounted crane with an approximate 200 ft long boom equipped with an eductor nozzle that is lowered into the surf zone for sand retrieval. This is the main difference between this option and Option 1.

The eductor hydrates the sand into a slurry and sucks the slurry into a 10" diameter slurry hose, drawn by a 420 HP mobile booster pump. This intake hose is surrounded by a metal, large- mesh screen framework to minimize the likelihood of intake of marine life (including sea turtles). The source of the water for the slurry is the ocean that is drawn into the system through a 420 HP jetwater pump, as in Option 1. The intake hose for this pump is intended to be floating just offshore, screened with metal mesh, and attached to a buoy. This will eliminate unintended sand or intake of marine life in the system. It is noted that the sealwater for this booster pump can come from a vertical well pump or fed from the ocean intake. From the mobile booster pump, the slurry is transported by the same system as described for Option 1.

Proposed Project Description

This Sand Slurry Pipeline system would maintain shoreline equilibrium by placing small volumes of sand on an annual basis. The project objective is to simulate the most natural possible sand transport and equilibrium along Sandy Hook in the context of the adjacent stabilization perturbation. This would require a pipeline that borrows sand from the northern, accreting portion of the Hook (Gunnison Beach) and deposits it on the eroding southern beach (Critical Zone). This system would provide NPS the flexibility of recycling from 0- to 100,000 cy annually (as needed) to maintain shoreline equilibrium. This system would utilize the sand moving through the Sandy Hook nearshore sediment transport in the form of longshore, swash bars, and migratory shoals.

The project entails the construction of a pipeline for the periodic transport of sand from Gunnison Beach to the Critical Zone at South Beach. It would pump a maximum of 100,000 cy during suitable weather conditions during the months of October through February. The quantity depends on accretion at Gunnison Beach and sand extraction is anticipated to occur primarily from the swash bar and migratory shoals that weld onto the beach face and extend the intertidal zone seaward.

Infrastructure to be constructed is described above, and is designed to be mobile and low impact with minimal footprint. It includes a slurry pipeline, concrete pads along the pipeline to support booster pumps, and connection points at each end of the pipeline to accommodate temporary pipe that would extend to the source and discharge beaches. Life expectancy of the pipeline infrastructure is estimated at 30 years.

The back-passing method proposed here is modeled after the facility specifications developed for the Indian River sand bypassing system in Delaware which is described in (Clausner *et al.* 1992, Rambo *et al.* 1991, Watson *et al.* 1993). That system, designed to move 100,000 cy/yr, has averaged 1500 cy/day on a 4 day/week, 6.5 days/month schedule within the Labor Day to Memorial Day window.

The dimensions of the excavated area produced by a stationary dredge are expected to be approximately 150'l x 60'w x 6'd. The excavation, however, would be conducted in the intertidal zone and on the attached migratory shoal where the slurry mixing is more efficient. Therefore, the excavation area begins to fill as quickly as it is created. A crane, situated near the berm above the high tide line, suspends the pipe and dredge (eductor assembly) out into the intertidal zone where it is able to excavate a trench about 150'l x 60'w x 6'd without moving its location. This is the largest area of excavation used at the DE site and anticipated at Sandy Hook. Typically, the dredge will remain in one stationary location all day as it dredges most efficiently in the intertidal zone. Depending upon the amount of sand in the migrating bars, the crane would stay in its location as new sand became available, or would move up to 3 times that distance to acquire more sand in the bar. At most the dredge area would cover up to 450 feet in length. Each time it moves, the depression left behind is expected to fill within two tide cycles from the natural current and sediments.

Once a shoal welds onto the beach face, the crane would be transported to the area immediately landward of the berm crest. The crane boom would then extend out to 150 feet or until the sand extraction was complete. The crane would be moved along the beach to follow the welded shoal along the Gunnison Public Beach. This process would continue as these bars would be targeted and sand extracted throughout the October through February window, the time when the shoals are most active and sand transport is maximized. Minimal beach disturbance is anticipated by the crane that would move only short distances and infrequently to tap these shoals. Disturbance to the intertidal zone is expected to be minimal, as longshore currents will continue to transport sand into the borrow sites. The crane would transverse the beach in one corridor and then move along the edge of the beach face to harvest the sand from the shoal as indicated in Figure 7.

With maximum borrow material (100,000 cy) removed, it would take 50 pumping days of 2000 cy/day. Recovery time for the deposition slurry is expected within two days after pumping, and with intertidal deposition it is expected that the depression would not be visible after two high tides. The NPS proposes to pump for 50 days from October through February at an average rate of 2000 cy per day. Because the passage of the migratory shoals occurs as a series of sediment pulses, the borrow period would attempt to capitalize on the pulse peaks, as detected by shoreline monitoring. At Gunnison Beach, the very high rates of alongshore sediment transfer would fill the dredge sites continuously during excavation, and largely eliminate the creation of sizeable craters in the beach face.

Figure 5 (a and b). Sand Slurry Removal at Borrow Site (Indian River Inlet, DE) NPS 10/24/01

View GRAPHIC 4 File

Figure 6 (a and b). Eductor Assembly Unit (Indian River Inlet, DE) NPS 10/24/01

View GRAPHIC 5 File

Figure 7 (a and b). Sand Slurry Deposition at Fill Site (Indian River Inlet, DE) NPS 10/24/01

View GRAPHIC 6 and GRAPHIC 7 Files

Slurry will be piped to the Critical Zone beach where it will be ejected out onto the beach face and intertidal zone. The pipe will be moved by dragging it with a tracked vehicle to build the Critical Zone up to the parking lots as needed. If it were deemed necessary to restore the fill area beach profile prior to March 1, bulldozers would be used to push any remaining sand mounds and restore the appropriate beach profile. Since, however, sand will be deposited seaward of the upper beach during the dynamic winter months, it is expected that the fill will be shaped by weather and ocean conditions. Protective fences or temporary barriers and educational signs will surround the project activity, both at the borrow and fill areas for public safety and education.

Various pipeline alignments were studied to find an alignment that was least disturbing to natural and cultural resources, park facilities and operation, visitation, park personnel safety and cost effects. The preferred pipeline alignment following the main Park access road was selected as a result of this process.

A monitoring program will be established to measure beach profile, erosion and accretion at various points along the Atlantic shoreline of Sandy Hook throughout the year, including Gunnison Beach and the nourishment site. Monitoring of the intertidal zone and beach profile at the borrow and fill areas in the spring and autumn for a period of three years to determine recruitment and recovery of macroinvertebrate populations will also occur. A comprehensive plover, amaranth and tiger beetle monitoring program will be adhered to in order to manage for these protected species.

Sand Requirements

The sand requirement is based on the need to keep the beach at the Critical Zone nourished enough to provide limited protection for the access road and park facilities and maintain a recreational beach. The NPS would like to place up to 100,000 cy annually at the nourishment site to provide and maintain a protective 100-foot wide berm. This volume was derived from historical data and littoral sand migration monitoring at Gunnison Beach. Dr. James Allen, Geomorphologist, United States Geological Survey, and Dr. Norbert Psuty, Geomorphologist, Institute of Marine and Coastal Sciences, Rutgers University, have documented accretion and erosion at Sandy Hook for 30 years (Nordstrom *et al.* 1982, Allen 1981, Psuty and Namikas 1991, Psuty 1992, 1993). Borrow sand at Gunnison Beach is the correct grain size for the nourishment site as determined by Dr. Allen and Dr. Karl F. Nordstrom (Nordstrom *et al.* 1982). The borrow site has been shown to be a dependable, replenishing source, based on experience and historical data.

The anticipated borrow area at Gunnison Beach would conform to the position of the migrating shoals seaward of the berm crest, but is anticipated to be around 450’ long, 60’ wide, and 6’ deep. With constant borrow area replenishment by longshore transport during borrow operations, the area would provide 100,000 cy of material for nourishment. The excavation at Gunnison Beach will be capture of sand that is moving through the area in the form of broad migratory shoals, extending from the beach face out to the nearshore along with a spit extension on the downdrift corner of the migrating shoal. These shoals migrate both onshore to weld onto the beach and alongshore to broaden the intertidal zone. At times, there may be no changes to the net beach conditions once the shoal have passed, but during other times, the beach may accumulate some of this sediment and widen as well as heighten (Psuty 2001).

Beach Profiles of Affected Areas in Relationship to Mean High Tide:

The annual mean tidal range is 4.6 feet (1.38 meters) above mean low water (mlw). The average spring tides are 5.6 feet (1.68 meters) above mlw. Borrow would start at mean high tide level and proceed seaward to acquire 100,000 cy. The berm elevation 400 feet (120 meters) landward of mean low water on the beach face is about 6 feet (1.8 meters) above msl. Excavation would not lower beach elevation, as no excavation would occur above the spring hide tide line. Sand slurry will only be taken from the intertidal zone seaward, as the slurry is more available and the operation is more efficient there. The dredging would temporarily lower the beach face but not the berm present in the Gunnison Area. It is anticipated that the intertidal grade would match the original slope within two days, as the primary target for sand extraction is the migrating nearshore shoal. Previous borrow at the site as well as experience at the Indian River DE site indicate that the borrow area will appear natural within the duration of a couple of tide cycles.

Figure 8. Slurry Extraction Schematic

View GRAPHIC 8 File

The borrow and nourishment sites will be surveyed on a regular basis to monitor beach profile, accretion and erosion. Monitoring will consist of topographic surveys before, during, and after project duration to record shoreline changes (biweekly surveys during pumping operations and monthly surveys the rest of the year at the borrow and nourishment sites). Quarterly surveys will document conditions along the full shoreline of Sandy Hook to assess sand transport, deposition, and beach response. Intertidal sampling will document benthic recovery and transects will record beach characteristics important to rare species.

The monitoring program will provide data to determine effects at the borrow and fill sites. The quantity of sand available in nearshore bars for nourishment will be determined prior to each nourishment cycle utilizing this monitoring protocol. Cross sections will be surveyed prior to, during and post excavation. Annual reports will be prepared to document beach recovery within an acceptable time frame to prevent critical beach loss near rare and T & E species reproduction areas.

Volumetric and Arial Measurements of Affected Area during High and Low Tides.

The maximum extent of the borrow is determined by the limits of the public beach area, the borrow required, accretion rates, and the difference between the total borrow and accretion during the borrow period (borrow deficit). The distance between fences is 1,580 feet. The crane will utilize a corridor from which to move along the beach berm to access the nearshore bars. Borrow will be extracted at or below mean low water level so that minimal beach disturbance, other than the infrequent crane movement, will occur. The dredge activity is expected to occur within an area of approximately 450 feet long x 60 feet wide x 6 feet deep. This area would be between Public Beach fences to provide a minimum100 foot buffer for the nesting areas to the north and south.

The accretion data collected between 1984 and 1994 represents the best available information on the dynamic sand transport system (Table 10).

Table 10. Cubic Yards of Sand at Borrow Site Source: Psuty 2001, Allen pers. comm.)

	Cubic Yards	Cubic Meters
Average annual accretion	210,000	160,600
Average annual pass through	300,000	229,400
Total Available Sand	510,000	389,900
Average daily rate of accretion:	1,400	1,062

The maximum size of the borrow area is determined by the borrow deficit. The borrow deficit is calculated by subtracting accretion during borrow from total borrow.

A natural beach slope will remain undisturbed, and the nearshore bottom will be quickly restored due to the physical properties of sand and wave action. Any potential remaining beach disturbance from extraction or pumping activities at the end of the borrow period would be normalized after the annual borrow is completed and at least one month in advance of anticipated piping plover return. Beach elevations (and flooding frequency) would remain the same. As stated earlier, the dune profile and beach berm would remain to protect the area from flooding.

IMPACT ASSESSMENT

Each of the identified alternatives has the potential for both beneficial and/or adverse negative impacts on the shoreline as well as the natural and cultural resources of the park, including protected species that occur within the Sandy Hook project area. Since 1976, NPS, has been pursuing and evaluating practical alternatives to address the altered sand budget problem and provide for continued operations and access to NPS resources, while minimizing adverse impacts to its exemplary cultural and natural resources. These alternatives were identified to meet NPS objectives and are impact analyzed in the following order: (A) No Action, (B) Slurry pipeline with crane and clamshell bucket for sand removal or eductor option for sand removal (preferred).

Alternative A – No Action:

The no-action alternative has the potential for both beneficial and adverse impacts to federally- or state-listed terrestrial species of concern, including piping plover, least tern, seabeach amaranth, seabeach knotweed, and the northeastern beach tiger beetle. No effects are anticipated for the aquatic marine mammals or sea turtles.

Potential Beneficial Effects

Piping Plovers

The No Action alternative has the potential to create alternate preferred back bay and overwash habitat with higher carrying capacity for a temporary period. Temporary overwash conditions due to no action may enhance and provide additional temporary breeding habitat, until natural processes succeed and revegetate these areas. A breach and new inlet formation might also provide temporary additional breeding and foraging habitats on the beaches of this new inlet. New east-west facing beaches with the potential for flat and pool development would provide improved foraging habitat for plovers as well as a potentially more sheltered beach conditions and higher productivity. Numerous Atlantic coast studies have documented the importance of beaches with bayside access, overwash and tidal bay flats on piping plover distribution and reproductive success including Coutu *et al.* 1990, Ellias *et al.* 2000, Ellias-Gerken 1994, Goldin 1990, Goldin and Regosin 1998, Hoopes 1993, Houghton *et al.* 1995-2000, Howard *et al.* 1993, Jones 1997, Loegering 1992, NPS and MD DNR 1993-1997.

These newly formed overwash areas could support nesting piping plovers, as has occurred on Westhampton Beaches in similar barrier breach conditions as Pikes and

Little Pikes Inlets (Houghton *et al.* 1995-2000). Enforcement and education will be critical in protecting these sites from the pressures of high public use at these highly visible and accessible community areas. This potential positive effect would not, however, avoid the immediate adverse direct impact of take.

Seabeach Amaranth and Seabeach Knotweed

Similar beneficial effects are anticipated for seabeach amaranth as it also occurs in the early successional, dynamic beach habitats similar to plovers. Amaranth occupies a narrow beach zone (0.2-1.5 m above mean high tide) including overwash flats and lower foredunes of non-eroding beaches and even secondary habitats like dune blowouts (Weakley and Bucher 1992). No action could create new, additional habitat in preferred backbay and overwash areas with higher carrying capacity for a temporary period.

Potential Direct Adverse Impacts

Piping Plover

The No Action alternative also has the potential to directly and adversely impact piping plovers, as storms and erosion would potentially occur when this species is present and utilizing the Critical Zone. This could result in loss of individuals, productivity, and habitat. If overwash was to occur, the additional habitat created would likely be sub-optimal, as overwashes would be within close proximity to structures and debris, resulting in a population sink, where productivity and nesting/fledging success could be lower than in more natural, undisturbed habitat. Human activity in the area is anticipated to be high as well as the potential for predation. The potential direct adverse impacts of flooding from more intensive overwashes or breach could cause adult and chick mortality or loss of eggs and habitat. Additionally, beach/dune repair and restoration could occur during the nesting season, resulting in direct impacts from construction activities. If repairs were made outside of the plover season, preclusion of high quality overwash/inlet/back bay habitat would still result.

Effects on least tern are expected to be similar to those on piping plovers as they inhabit similar environments and often occur concomitantly.

Seabeach Amaranth and Seabeach Knotweed

These species may experience the adverse potential of direct impact if flooding was to occur in these newly formed habitats. This could result in loss of individual plants and the seed bank. Since they are intolerant of flooding, amaranth could experience low productivity (loss or burial of seed bank) or mortality in active overwash or breach conditions. Therefore the no action alternative has the potential to directly affect these species, as storms and erosion would potentially occur at the time of year when they were present.

Northeastern Beach Tiger Beetle

This species has the potential to be adversely affected by the No Action Alternative from increased erosion and flooding caused by hurricanes and winter storms. These decrease the amount of habitat available for adults and larvae and are leading causes of larvae mortality and overall population decline.

Sea Turtles and Marine Mammals

No effects are anticipated for the aquatic marine mammals or sea turtles or their potential habitat. Only in the unlikely event of a breach would they be impacted, and then the short and long-term effects are unpredictable as to whether they would be positive or negative.

Potential Indirect Adverse Effects

Piping Plovers

If "No Action" were taken to reduce or modify the ongoing rates of erosion, the sand deficit in the Critical Zone would continue to occur and the spit would be breached. Initially, an overwash area would be created, connecting the ocean and bay. This overwash habitat is prime nesting and foraging habitat for piping plovers and is presently absent from Sandy Hook. This overwash, however, is predicted to be only a temporary condition as evidenced by history and confirmed by coastal geologist opinions (Psuty and Allen pers. comm.). Since the area is so narrow, the overwash zone would soon be expected to breach and form an inlet.

Once a breach develops, it is expected to be a highly dynamic inlet. Strong tidal flow through the uncontrolled inlet would cause accelerated erosion on both ocean and bayside beaches. Significant changes in bay and ocean circulation patterns, water quality, and biota could be expected (Psuty and Allen pers. comm.). The already existent sand deficit northward to Sandy Hook could increase due to the entrapment of sand in the formation of the flood tide delta. This condition would exacerbate the erosion along the southern portions of Sandy Hook and reduce the amount of available beach for wildlife and recreation. It is believed that the inlet would be highly dynamic, and due to the sand deficit in the area, widen significantly. This wider inlet would rob some of the sand that would be transported north to Sandy Hook ocean beaches to form a flood tide delta.

The size, duration and general conditions of such an inlet are difficult to predict, but are unlikely to remain stable. There is also the possibility for the inlet tip to become attached to the mainland, or to migrate significantly as in the past (Moss 1964). The most certain prediction is that, due to the sand deficit there, it would be a highly dynamic area and would reduce the amount of sand available for transport north along the Sandy Hook ocean shoreline.

This accelerated beach erosion would have an impact on the existing distribution and success of the flora and fauna of Sandy Hook. Nesting by piping plovers in the Critical Zone and along southern beaches would likely be adversely affected as ocean beach habitat continues to be lost there. The sand deficit would increase, impacting the rate of accretion and available habitat along the northern beaches that presently support the rare beach flora and fauna.

Temporary overwash habitat may be created with continued erosion of southern beaches. A breach and new inlet formation might also provide temporary additional nesting and foraging habitats on the north and south beaches of this new inlet. New east-west oriented beaches with the potential for flat and pool development would provide improved foraging habitat for plovers as well as a potentially more sheltered beach condition. These habitats are now rare on Sandy Hook. Numerous Atlantic coast studies have documented the importance of beaches with bayside access, overwash and tidal bay flats on piping plover distribution and reproductive success including (Cape Lookout NS 1998, Coutu *et al.* 1990, Ellias, *et al.* 2000, Ellias-Gerken 1994, Goldin 1990, Goldin and Regosin 1998, Hoopes 1993, Houghton *et al.* 1995-2000, Howard *et al.* 1993, Jones 1997, Loegering 1992, NPS and MD DNR 1993-1997). The state of sand starvation at the site of the new inlet due to the presence of the seawall, however, would severely limit flat and bar formation (Psuty pers.com.).

Another aspect to consider in habitat suitability is human disturbance. Numerous studies have documented the direct and indirect adverse effects of human disturbance on piping plovers (Burger 1987, Melvin *et al.* 1992, Howard *et al.* 1993, Ellias-Gerken and Fraser 1994, Strauss 1990). These newly-formed overwash areas should support nesting piping plovers, as has occurred on Westhampton Beaches in similar barrier breach conditions as Pikes and Little Pikes Inlets on Long Island, New York (Houghton *et al.* 1995-2000). If these areas were protected from the high public use pressure at this highly visible and accessible site at the entrance to the NPS, new natural beach communities may develop.

Since the ocean beaches already receive high public use and have protected areas for rare flora and fauna, no shift or change in existing use is expected. This is also the case with human induced predator impacts, as both beach conditions and predator populations fluctuate and cycle. The location and accessibility of a potential new inlet, however, may perpetuate the existing “attractive nuisance” condition at the site and require intensive enforcement for public safety and resource protection concerns. The high visibility of the area and accessibility by land and water makes this site very prone to random human disturbance events, as already witnessed. Also, the dynamic nature of this inlet might create suitable habitat for T & E species, but is predicted (Psuty and Allen pers. comm.) to be highly dynamic due to strong currents into the Ruritan Bay system, and be subject to higher tides and flooding due to increased water volumes into the Bay.

It is therefore uncertain whether the new overwash or inlet formation would be a net short or long-term gain or loss of quality beach habitat to support T & E species, as the existing Sandy Hook beaches might be reduced by this exacerbated sand deficit of inlet formation. Existing beaches might narrow and become less suitable for beach flora and fauna with increased sand deficit in the longshore transport due to inlet formation.

A breach of the spit would also cause the loss or overwash of portions of the area’s holly forest, maritime forest, and intertidal wetlands. Perhaps the most significant impact, however, would be the resultant habitat fragmentation and geographic isolation of Sandy Hook’s biotic community. The maritime holly forest is a resource of national significance. Alteration or loss of the forest would be the direct result of the sand deficit caused by the seawall and hard structures south of the Park. Failure to offset the sand deficit or provide protection to the forest would result in a long-term major impact. The complex spatial and temporal morphological changes to the shoreline remain uncertain, but would occur within the framework and context of NJ's highly manipulated coastal system delivering a negative sand budget into the Sandy Hook System.

Cumulative Effects

The no-action alternative could affect listed species either positively or negatively, due to the dynamic and uncertain results and duration of coastal processes. A variety of historic, on-going and planned activities will continue to affect these species. If an inlet forms, a sand deficit may rob northern beaches and decrease the amount of suitable beach habitat long-term. If an inlet is formed and remains long-term, then additional suitable habitat is expected along the new inlets, as sand deposition will be deflected to this new location. Recreational use/facilities in areas throughout the park have resulted in habitat loss and degradation to threatened and endangered species. Associated human disturbance is likely to be a factor in the foreseeable future, even if no action is taken to stabilize the shoreline. Planned continuance of ACOE Monmouth County shoreline stabilization projects to this adjacent area precludes the natural habitat formation in the New York/New Jersey area and coastwide for the foreseeable future.

Table 11. Potential Effects Of The No Action Alternative On Special Status Species

Common Name (Scientific Name)	Potential Effect
Piping plover (*Charadrius melodus*)	**Potential to have minor to moderate positive or negative impacts if species is present (Potential for direct impact of take.) Potential indirect impacts of habitat formation and suitability , including ocean-side beach and foredunes and bayside foraging areas could be increased or decreased—unpredictable.**
Seabeach amaranth (*Amaranthus pumilus*)	**Potential to have minor to moderate positive or negative impacts. Potential habitat, including ocean-side beach and foredunes and bayside areas could be increased or decreased—unpredictable. Potential loss of individuals and seedbank in the event of flooding.**
Seabeach knotweed (*Polygonum glaucum*)	**Potential to have minor to moderate positive or negative impacts. Potential habitat, including ocean-side beach and foredunes and bayside areas could be increased or decreased—unpredictable. Potential loss of individuals and seedbank in the event of flooding.**
Least tern (*Sterna antillarum*)	**Not likely to adversely affect to moderate positive or negative impacts. Potential habitat, including ocean-side beach and foredunes and bayside areas could be increased or decreased—unpredictable.**
Northeastern Beach Tiger Beetle (*Cicindella dorsalis dorsalis*)	**Potential to have minor to moderate negative impacts. Increased flooding and erosion caused by storms may decrease habitat available to all life stages. Additional indirect impact potential for minor to moderate positive or negative impacts. Potential habitat, including ocean-side beach and foredunes and bayside areas could be increased or decreased—unpredictable.**
Finback whale (*Balaenoptera physalus*)	**Not likely to adversely affect. Species not likely to be present and potential habitat would not be affected.**
Humpback whale (*Megaptera novaeangliae*)	**Not likely to adversely affect. Species not likely to be present and potential habitat would not be affected.**
Right whale (*Balaena glacialis*)	**Not likely to adversely affect. Species not likely to be present and potential habitat would not be affected.**

Green sea turtle (*Chelonia mydas*)	**Not likely to adversely affect. Species not likely to be present and potential habitat would not be affected.**
Loggerhead sea turtle (*Caretta caretta*)	**Not likely to adversely affect. Species not likely to be present and potential habitat would not be affected.**
Kemp's ridley sea turtle (*Lepidochelys kempii*)	**Not likely to adversely affect. Species not likely to be present and potential habitat would not be affected.**
Leatherback sea turtle (*Dermochelys coriacea*)	**Not likely to adversely affect. Species not likely to be present and potential habitat would not be affected.**
Hawksbill sea turtle (*Eretmochelys imbricate*)	**Not likely to adversely affect. Species not likely to be present and potential habitat would not be affected.**

Action Alternative

Impacts To Shoreline Processes.

Continual replenishment of the beach with smaller quantities of sand on a regular basis would more closely mimic the amount of sand transported through natural shoreline dynamics. Sediment will be removed in transit from shoals as they weld to the beach face or nearshore. The area inland of the spring high tide at Gunnison would not be excavated. The sand would be secured from the mobile pulses of sand passing through the area as migrating shoals. The dredge hose would essentially work the beach face below the high tide line across the welded shoal, and seaward into the subaqueous environment.

Whereas the original thought was to pull the sand out of the existing dry sand accumulation in the Gunnison recreational beach and let the migrating shoals replace the excavated sand, the preferred alternative is now to excavate the sand from the migrating shoals as they pass through the Gunnison area. Early estimates calculated the sand volume in these migrating shoals to be on the order of 10,000 - 20,000 cy encompassing an area seaward of the existing berm crest and extending seaward to 0.0 elevation (NGVD29). There is a shoal at Gunnison at present that has a volume of about 25,000 cy above 0.0 and about 40,000 cy above mean low water. And there are two more shoals seaward of it. The shoals are more prominent and more dynamic in the winter season. Winter excavation would be more likely to fill quickly and have less of a downdrift effect. There are shoals in the summer but they tend to migrate much more slowly and are used by the recreationists because they are sites of shallow water.

The crane would work the shoal from an elevation above mean high water and tap the sand which is passing through in the form of the shoal and also the sand that is migrating across the shoal in the form of surface ripples and sand waves. This latter material will be the source of sand to fill the crater as the sand is being excavated. Removing sand from the migrating shoal would tend to leave a depression. However, the longshore transport rates accompanying the presence and passage of these shoals are sufficient to quickly replace the excavated sand and to minimize the topographic perturbation. This would be especially true for any excavation in or below the intertidal zone where the alongshore transport of sand occurs. Further, dredging in the October to February period takes advantage of the higher wave energies of the winter period and thus it will coincide with the greater rates of alongshore sediment transport.

Prediction of the length of shoreline to be affected is difficult because of the assumptions required (i.e., wave energy and direction components driving beach response and sediment transport) but is expected to be less than 500 feet beginning about 100 feet north of the south fenceline. There is no anticipated effect updrift of the excavated area except some limited caving of the small crater at the time of excavation. There may be some small effect on the downdrift displacement and extension of the shoal, in proportion to the quantity of sediment siphoned off to be transported to the Critical Zone. Importantly, the sand will stay within the Sandy Hook nearshore transport system as it is recycled from the eroding beach to the accreting area, and back again.

Beach steepness would not change from its present range because steepness is dependent upon sediment grain size and wave parameters. The area of bare sand habitat on the beach would remain unchanged, but would be displaced landward because this feature is dependent upon wave overtopping of the beach berm and its envelope of annual excursion. Beach elevation is dependent on tidal range and wave runup heights. These would remain unchanged and so beach elevation (and flooding frequency) would not change. There would be no change in all known attributes other than surface area, which is ample, because there is no arresting of the natural processes taking place. Small deviations from the norm could be expected for up to one tidal cycle (a little over 12 hours) after sand mining, but this effect would be minor.

Construction activities would affect approximately eight (8) acres of vegetation in almost all areas of previous disturbance (roadside) or shoreline shrub areas to establish the pipeline. Approximately one half acre of dune shrub habitat would be impacted as the pump house facility would be located behind the dunes. Every attempt would be made to utilize previously disturbed areas there. Vegetation losses would be mitigated by the revegetation of disturbed sites with native species matching those that existed in the area prior to construction. Failure to follow facility removal with an active and ongoing revegetation program using native plants and seeds could have the effect of providing favorable conditions for the invasion of non-native plants and noxious weeds that flourish in disturbed sites such as road corridors.

The beach fill would be dispersed from a site near the location of the concrete blocks in the beach (a station near the road and extending a pipe seaward to the beach). The quantity of sand moved would be related to the deficit determined by monitoring of the Critical Zone topography. The sand would be put into the intertidal zone and subsequently transported downdrift by the ambient waves and currents. Or, if the shoreline had been seriously eroded, the sand could be used to build the subaerial profile. Tracked vehicles would be required to move the pipeline around to the eroding areas, and to possibly move sand in the vicinity of the outfall for the pipeline, if required to restore the beach profile.

Removal of sand from Gunnison Beach is not likely to adversely affect the piping plover since this beach is not currently used by nesting plovers. Past experience with removing sand from Gunnison beach indicated that sand was replaced by longshore transport almost as quickly as it was removed. In addition, there would be no net loss of plover habitat since only that portion of the beach that is accreting on an annual basis would be removed. The only potential loss is the prevention of overwash and back bay habitat formation, which is expected to be a temporary condition.

There is the potential for sand removal to affect accretion rates on beaches at the north end of the island, thereby affecting plover and tiger beetle habitat, however, because only small quantities of sand will be removed at any one time, any effects should be minimal. Also, annual surveys of the full ocean shoreline of Sandy Hook will be conducted via a vehicle-mounted GPS receiver and entered into the digital atlas of shorelines to continue to assess conditions of sand transport and beach response all along the spit.

It is anticipated that the proposed slurry excavation and deposition will temporarily increase suspended sediments and turbidity in the surrounding area (up to 3 acres total) as alongshore currents and breaking waves disperse the suspended sediments from the slurry site. This affect is expected to be temporary and localized as tides and wave action will quickly restore sediments to normal conditions in this highly disturbed, dynamic mixing zone along the beach and intertidal zone. Temporary, minimal disruption of the benthic prey organisms and the food chain is expected within the borrow and fill sites.

Alternative B - Slurry Pipeline

Potential Beneficial Effects

Piping Plovers

Beach replenishment could have a beneficial effect on rare beach flora and fauna, including the plover and amaranth, since it would restore habitat for these threatened species at the Critical Zone and provide for continued accretion on important northern beaches. Erosion has already eliminated much of the plover's habitat at the Critical Zone and is continuing to limit nesting and feeding habitat there. The number of plovers nesting there has decreased from a high of 6 pairs in 1995 to 2 in 1996, and then experienced a hiatus until 2001 when 1 pair nested and fledged 1 chick. In 2003, although 4 pairs nested at the Critical Zone, only 3 eggs hatched and only 1 chick fledged. Low numbers are believed to be the result of limited nesting habitat and very limited foraging habitat from the erosive beach profile.

If the result of the beach nourishment produces a higher, wider beach and more available, suitable habitat for amaranth, terns and plovers, there can be potential positive habitat impacts. This could reduce flooding and potential loss of individuals and progeny and provide additional habitat for more colonization. Sand manipulation would also provide a gently sloping beach and wider intertidal areas for increased plover breeding and foraging.

Beach nourishment is likely to result in minor short and long-term impacts to the beaches along Sandy Hook. The nourished beach profile, more closely simulating that of natural processes sediment placement, dimensions and function, will have less impact than the historical/typical fill design. The gentler beach slope will reduce beach scarping, allow for natural wrack line establishment, nutrient and seed dispersal and recolonization by native beach flora and fauna. Least terns are expected to experience the same benefits as piping plovers from this alternative.

Seabeach Amaranth and Seabeach Knotweed

Similar beneficial effects are anticipated for seabeach amaranth and seabeach knotweed as it also occurs in the early successional, dynamic beach habitats similar to plovers.

Northeastern Beach Tiger Beetles

Similar beneficial effects are anticipated for the beetle, as creation of additional habitat and simulation of natural sediment deposition and coastal processes are expected to maintain the early successional, dynamic beach habitats.

Potential Direct Adverse Effects

Direct impacts on listed species are not anticipated because the criteria for beach nourishment activities restrict construction to the time of year when species are not present to avoid and minimize take. Plovers, turtles and whales are not expected to be present, and amaranth, if present, is expected to have peaked in seed production and dispersal, and neared the completion of its annual cycle. Northeastern beach tiger beetles have not been detected at Gunnison Beach or the Critical Zone, but continued surveys will provide for detection of larvae and adults. Tiger beetles had been reintroduced onto North Beach at the northern portion of Sandy Hook as part of the Atlantic Coast recovery effort, but none have been recorded near either the withdrawal or deposition areas. Protection measures will be implemented for any individuals located at either site and FWS staff will be consulted if surveys indicate that beetles have moved into the project area. This species is not expected to experience any effects from project activities. Therefore, there will be no further discussion of potential impacts to this species.

This alternative will increase the available habitat at the fill area or Critical Zone. There is always a chance that a rare plant or animal species may accidentally occur during project activity, but surveys and monitoring protocol should determine this and immediately trigger species protection and project modification as outlined in mitigation measures.

Piping Plovers

This Alternative is not expected to have any direct adverse effects on piping plover. Time of year restrictions make it unlikely that this species will be present during the project period. A requirement of beach nourishment is to conduct surveys for this species (per FWS conservation measures protocol) prior to and during such activities so that species status is accurately determined. In the unlikely event that plovers are present, then no nourishment will be conducted until they have left the area.

State endangered least terns and the piping plover, have historically nested at the Critical Zone. Years following major beach fills have resulted in the greatest numbers of nests. All fill activities will occur outside of the nesting season and would therefore have no direct effect on shorebirds. Fill activities will be completed by March, allowing re-population of intertidal invertebrates, a preferred shorebird food source. Nests which may occur on the new fill will be protected in accordance with the FWS Recovery Plan and the Sandy Hook Unit Piping Plover Management Plan.

Seabeach Amaranth and Seabeach Knotweed

Seabeach amaranth and knotweed plants could be directly impacted under Alternative B, as sand would be placed on sections of beach requiring some manipulation of the beach area by construction equipment. Beach nourishment which is conducted in the winter would likely have minimal impacts to the adult plants as they will already have set seed. Deeply burying seeds with several feet of sand may also affect their ability to germinate in the next growing season, having potential deleterious effects on local populations. The severity of the impacts depends on the depth of burial, erosional climate, the nature of seabeach amaranth's seedbank, and the importance of long distance seed dispersal to outlying population maintenance. In addition, any seeds dispersed to the project area from nearby populations prior to beach nourishment would likely be buried after beach nourishment commenced.

In the unlikely event of amaranth presence and construction activities unable to avoid plants physically or seasonally, plants could be transplanted to similar nearby project site habitat and protected through fencing and educational signs and monitoring. Transplantation itself is not without adverse effects, however. It poses direct adverse effects to the plant as it requires digging up the plant(s) and physically moving it to another environment (FWS 2002a, 2002b, 2003). An additional measure to minimize and compensate for any amaranth direct take, seeds would be collected and germinated (per FWS protocol, FWS 2002a and b) and replanted in the project site and protected. However, because the slurry pipeline is designed to place small volumes of sand eastward of rare plant occurrences, it is not expected to have any direct effects.

A requirement of beach nourishment is to conduct surveys for this species (per FWS conservation measures protocol) prior to and during such activities so that species status is accurately determined. If amaranth is present, then protective fencing (per FWS conservation measure protocol) will be used as a buffer and monitored until natural annual mortality occurs. Burial of the seed bank with sand placement during beach nourishment is also a potential adverse impact.

Seabeach amaranth has recently recolonized the project area, presumably as the result of ACOE dredging operations immediately to the south. Most of the plants located during the recent survey occurred below the berm. Surveys will continue on an annual basis, and prior to project commencement. If any plants are located, they will be protected and seeds will be harvested per FWS guidelines. The FWS and NPS have established a procedure for conserving and mitigating seabeach amaranth on Sandy Hook in relation to ongoing projects, and NPS will continue to follow FWS guidelines and coordinate with FWS staff towards its protection. Beach conditions are not expected to adversely impact tiger beetles, as larvae and adults will continue to be protected on accreting beaches further north and monitored through annual surveys.

Northeastern Beach Tiger Beetles

No direct effects are anticipated for the beetle, as creation of additional habitat and simulation of natural sediment deposition and coastal processes are expected to maintain the early successional, dynamic beach habitats.

Sea Turtles and Marine Mammals

Due to the time of year restrictions for this proposed pipeline operation, temporary minimal impacts are expected. Neither sea turtles nor marine mammals are expected to be present in the project area during pipeline operation and sand deposition. Most EFH species are absent during the project time as well, except winter flounder. However, in the event that individuals are present and the clamshell bucket is used for sand removal, there is the potential for adverse impacts in that they could get scooped up by the clamshell bucket and placed into a hopper container where the sand is mixed with water to create a slurry before being pumped into the pipeline.

Beach fill activities are not expected to have adverse direct impacts on sea turtles or marine mammals, as these activities are restricted to above mean high tide and only localized aquatic habitat would be temporarily impacted as sediment may enter and mix from the intertidal zone. Because these activities are confined to the late fall and winter months when beach processes are highly dynamic, effects are expected to be minimal, and species are not likely to be present (Ruben and Morreale 1999, NMFS 1995).

Borrow activities, on the other hand, have the potential to adversely affect sea turtles and marine mammals if conducted during the time when they are present. Studies show that sea turtles utilize the New York waters in the warm seasons from June through October, and leave the area with falling water temperatures in September and are gone in early November (NMFS 1995, 2003). The listed whale species are considered transient to the area and are not expected to be in the action area. Previous studies and NMFS biological opinions indicate that nourishment projects off the south shore of Long Island and northern New Jersey are not likely to adversely affect listed whales, but may adversely affect sea turtles if conducted in June through October with hopper dredging equipment (NMFS 1995, 2003). Hopper dredge equipment will not be used for this project, however. NMFS further requires borrow area sampling prior to construction and trained NMFS observers to monitor the first cycle of dredging operations.

It has been further determined that few turtle interactions have been observed in monitored nourishment projects through 1995 (NMFS 1995, 2003). Dredging equipment will be restricted to avoid and minimize potential effects to sea turtles, but there is the potential for them to get scooped up into the clamshell bucket during sand removal. However, according to NMFS (1995, 2003) clamshell and other similar dredges do not characteristically impact sea turtles. Conservation measures to avoid, minimize, and mitigate for any possible impacts would be followed per NMFS guidelines.

Since typical dredging operations have the potential to adversely impact sea turtles, marine mammals and other marine life through entrapment in the dredge, operations would not be scheduled between March and November. This atypical dredge design, restricted to the surf zone is less apt to encounter or entrap marine life. The seasonal window is also limited due to plover nesting activity between mid-March and mid-August and EFH considerations year round. This leaves a narrow window of opportunity for dredging to occur during the months of October through February, a period when winter storms are frequent.

Sand extraction activities have the potential to directly affect the life stages of flounder and bluefish. They, too, have the potential to be scooped up into the clamshell dredge bucket. However, due to the time of year and the small area of shallow, highly disturbed intertidal and subtidal habitat immediately adjacent to the beach, it is unlikely that these species would be present and likely that effects are minimal in this highly dynamic and transitory habitat. Because these species are mobile, they are likely to avoid this area of disturbance.

Implementation of Option 2 which calls for the use of an eductor to remove sand instead of the clamshell bucket would further minimize the potential impacts on finfish, marine mammals and sea turtles because the equipment size and design minimize the potential for any direct impact to these species. The eduction area is small (6"), and water spraying out from the nozzles ahead of it to create the slurry is likely to deter any mobile life stages from the area. This eductor equipment is much more localized and less impacting than typical dredge equipment, therefore minimal direct effects are anticipated. Further, the eductor is encased in a metal sheath and the area of slurry intake is surrounded by a metal rod "screen" of 4-6 inch mesh which would prevent larger organisms from getting sucked into the equipment.

Potential Indirect Adverse Effects

General

Impacts on air quality resulting from equipment exhaust and fugitive dust would be localized, short term, and minimized with the use of the newest filters and technology for these high efficiency pumps. Normal conditions would return once the project is completed. Since the project window occurs outside of the sensitive season for T & E species as well as recreational use, impacts are expected to be minimal.

There would be above-ambient noise levels associated with this project. The noise level, however, would not be excessively loud, and all work would be completed in the shortest time possible. Increased noise would result primarily from the use of heavy equipment. These greater-than-ambient noise levels would carry approximately one-quarter mile past the project area. Since the project would be completed during the non-breeding season, and outside of the sensitive time period deemed by FWS and NMFS, noise levels are not expected to be a significant adverse impact on rare wildlife.

Construction and operation of the pipeline is not expected to have an effect on sensitive plant species, or result in adverse effects on wetland functions or values. Nor would there be negative impacts on freshwater ponds, existing drainage patterns, or beach dunes, as the pipeline would be placed behind the dunes and along roadside areas.

Piping Plover

Potential indirect impacts are anticipated to plovers as beach profiles will change within and adjacent to the project areas where these species may be present. While sand placement could benefit plovers by providing more habitat, creating additional habitat in heavily disturbed recreational areas could result in sub-optimal or nonfunctional habitat, which could also result in a population sink. Wider, higher beaches could attract and result in higher recreational use and an increase in predation due to the availability of additional habitat for fox dens. Numerous studies have documented the direct and indirect adverse effects of human disturbance on piping plovers (Burger 1987, Melvin *et al.* 1992, Howard *et al.* 1993, Ellias-Gerken and Fraser 1994, and Strauss 1990). Since these community ocean beaches already receive high public use no significant shift or change in existing use is expected. This is also the case with human induced predator impacts, as both beach conditions and predator populations fluctuate and cycle.

Beach building could preclude natural overwash processes and early successional habitat formation in the short term. Sand fill would bury established beach vegetation and temporarily retard vegetative growth. Nourishment could also bury or temporarily remove the wrack line, an important source of prey for plovers. Recognition that this habitat is in front of developed areas, subject to increased visitation and disturbance, is also an important consideration in this impact analysis.

Placement of the fill would prevent or limit overwash at the Critical Zone. Overwash areas are favored habitat by piping plovers. The discussion of Alternative A presented the numerous studies that document positive piping plover responses to bayside and overwash habitat as has the ACOE (1994) in a similar discussion and review of alternatives at Assateague National Seashore. Although it is not now the plover's most productive overwash habitat, preventing or limiting this ocean beach habitat formation could have a limiting effect on the production of new piping plover habitat, numbers and productivity on Sandy Hook.

Seabeach Amaranth and Seabeach Knotweed

Habitat effects on amaranth and knotweed are expected to be similar to those on piping plover because they occupy similar environments. Potential creation of new habitat is a positive effect, but loss of habitat and burial of seedbank is a potential adverse effect in the fill area.

Northeastern Beach Tiger Beetles

Similar effects are anticipated for the beetle, as creation of additional habitat and simulation of natural sediment deposition and coastal processes are expected to maintain the early successional, dynamic beach habitats along the Park.

Sea Turtles and Marine Mammals

Since turtles are mostly subsurface, observed most frequently in depths less than 15 m, they are thought to be using the New York waters as important feeding habitat for growth and development. Both borrow areas occur in 40-50' deep waters and the cut depth would range from 5 to 8 feet below the existing surface. An important concern is to protect the benthic food resources within shallow embayments that serve as feeding grounds (Morreale and Standora 1994). It has been determined that NY borrow areas may contain benthic resources, that turtles may utilize deeper waters (greater than 15 m for resting or foraging), although infrequently in NY and NJ. While some turtles reside in shallow bays, others transit the NY Bight frequently during a season.

No indirect effects on whales are expected as they will not be present in the project area during any borrow/fill activities.

Piping Plover/Sea Turtle Prey Base

These nourishment impacts include potential repetitive disturbance of benthic communities at the borrow and nourishment sites, filling of intertidal and subtidal areas, interrupting the natural dynamics of barrier island migration, and increased turbidity during the dredging, filling and beach erosion components of each project cycle. Potential indirect adverse impacts include loss of habitat, decreased foraging opportunities with similar impacts to the aquatic resources that depend on this portion of the Atlantic Ocean to complete or sustain portions of their life cycle.

The US Army Corps of Engineers, through its Biological Monitoring Program (BMP), analyzed data collected for a restoration project to the south of Sandy Hook between Asbury Park and the Manasquan River (ACOE 1998). Local sampling methods were not comparable to those of the BMP of ACOE, and no data exist on benthic fauna of the Critical Zone area (Eddings *et al.* 1990), but due to the proximity of Sandy Hook to the ACOE sampling areas, the fauna is expected to be very similar.

Macroinvertebrate populations are subject to significant seasonal variations. However, the Corps study identified high densities at specific sites and times rather than a consistent difference between areas, stations, or seasons. In terms of impacts to the fauna in the swash zone, there was no statistical difference in abundance, diversity, composition, or total biomass between samples collected before and after nourishment in their adjacent study areas (ACOE 1999a, 1999b, 2001a). The ACOE BMP found that complete recovery of the intertidal infaunal assemblage occurred between two months and six and one half months. Because the area of impact is relatively small in the proposed pipeline project, recolonization is expected to occur much more rapidly than in the more extensive adjacent beach fill projects and is expected to recover within several tide cycles or two days.

Gorzelany and Nelson (1987) reported no significant reduction of the number of individuals or the mean number per core for studies conducted at a sub-tropical beach in Florida. Nelson (1993) reported the physical characteristics of the fill strongly influence recovery rate and species composition. Two studies showed decrease of *Scolelepis squamata* associated with the use of poorly matched borrow. Nelson also reported that beach communities are adapted to large scale sediment disturbance as suggested by observed response to major storm events with no persistent effects.

Van Dolah *et al.* (1992) reported that at Hilton Head S.C., effects in the surf zone were of short duration and small compared to natural seasonal fluctuations. No drastic changes were observed in species composition or relative abundance of major taxa at any nourished sites. Rapid recovery was attributed to similarity of fill to existing sediment. Recovery was observed in less than 3 months. At Folly Beach NC, Van Dolah reported that benthic infauna inhabiting the beach and surf zone recovered rapidly and that infauna inhabiting the surf zone were least affected, if at all. In general, polychaetes increased in relative abundance on the beach during the three-month post-nourishment sampling period (ACOE 1994).

Studies conducted in Florida, North Carolina, and South Carolina show that recolonization rates by benthic invertebrates are variable and somewhat dependent on the time of year in which the nourishment occurs, beginning within days and taking up to one year for full recovery of some species (Reilly and Bellis 1983, Bacca and Lankford 1988, Lynch 1994). The macrofaunal community after recolonization may differ considerably from the original community. Once established, it may be difficult for species of the original community to displace the new colonizers (Hurme and Pullen 1988).

All studies indicated grain size significantly influences recovery rates and post-nourishment species composition. The sand at the proposed borrow area on Gunnison Beach was placed by littoral drift, and as projected, will be carried back to the borrow area by the same process. Residual sand at the borrow is the same size as sand accreting at the site. Because particle size is the same, no change in abundance, diversity, composition, or total biomass would be expected.

Based on the literature search, benthic recovery at the intertidal zone would occur rapidly. Recruitment would primarily occur through pelagic drift of juvenile and adult organisms from adjacent areas. In limited areas of intertidal borrow, benthic organisms would be continuously populating the intertidal zone as borrow is taking place. In the fill area, recruitment is expected to primarily occur through pelagic drift of juvenile and adult organisms from adjacent areas south of the Critical Zone.

Intertidal infauna within the immediate (50ft x 50ft) borrow site are expected to be removed through the use of a clamshell bucket or an eductor. However, due to the small area impacted at any time, recolonization is expected to occur within 2 days at both the fill and borrow sites as the dredge moves slowly to respond to the next site of accreting shoal. In some cases, the dredge may not move for days, depending upon the availability of sand in the attaching shoal.

The proposed water work effects on finfish are expected to be minimal because of the time of year restriction. All in water work will be completed at times when most of the finfish species are not expected to be present. Since winter flounder move to the estuaries to spawn from February to June, there is the potential for them to be present; however, the both the adults and juveniles, being mobile, are expected to avoid the relatively small area of disturbance. The EFH disturbance is relatively small scale, totaling less than an acre or 27,500ft^2 over a four-month period. At any one time, an area less than 2500ft^2 will be impacted, as longshore currents and sediments will fill the depressions within 2 tide cycles.

The effects of dredging and fill placement are influenced by the conditions at the dredging site, by the nature of the materials dredged, and, both directly and indirectly by the types of equipment used. By their nature, dredge borrow and fill activities may result in the following temporary and localized indirect impacts:

- Increased levels of turbidity and suspended solids possibly resulting in:
  - Reduction of dissolved oxygen levels.
  - Gills and filter-feeding structures becoming clogged.
  - Destruction of benthic organisms entrained within the dredging device.
  - Altered benthic diversity following recolonization.
  - Changes in circulation patterns.
  - Modified sediment deposition.
  - Creation of either hypoxic or anoxic zones.
  - Modified behavior of organisms due to increased stress levels possibly affecting reproduction.

Due to the design of this project, however, sand removal will be restricted to the highly dynamic surf zone with smaller quantities of sand removed outside of the sensitive biological and visitor use periods. The frequent digging movements of the clamshell bucket will carry sediment in and out of the water column. Conversely, use of the eductor for sand removal will result in less sediment in the water column because the eductor will remain in the sand. These impacts are expected to be minimal.

Cumulative Effects

Although coastal processes are difficult to predict and highly dynamic, there are negligible to minor cumulative impacts expected from the project. The implementation of this long-term proposed beach restoration project is intended to recapture sediment that is passing through the system (that would be lost to the channel due to the Monmouth Co beach fill perturbation) and recycle it back to the erosive southern end in the least intrusive way, maintaining the barrier spit. It is one of the numerous NJ shoreline stabilization projects, therefore contributing to the overall loss of natural coastal habitat. However, this project is in response to the adjacent pre-existing man induced changes which threaten Park Resources and Mission, and attempts to simulate the most natural shoreline processes possible through this sand recycling method.

Table 12. Potential Effects Of Alternative B On Special Status Species.

Common Name (Scientific Name)	Potential Effect
Piping plover (*Charadrius melodus*)	**Negligible to Minor negative or positive effect. Beach nourishment would result in a wider beach with more foraging and nesting habitat. Since birds are not in area during construction time, no direct adverse impacts anticipated. Surveys, monitoring and FWS protocol will be followed. Potential indirect negative effects: preclusion of natural and overwash habitat, creation of sink/sub-optimal habitat, burial/manipulation of prey base, increased recreational and predation impacts. Potential to adversely affect, but species not expected to be present during project period.**
Seabeach amaranth (*Amaranthus pumilus*)	**Minor to moderate negative or positive effect. Beach nourishment could result in mortality to plants or burial of seed bank if conducted outside of safety window or protocol. FWS guidelines will be followed to avoid, minimize and compensate, including surveying, fencing and monitoring. Nourishment could result in a wider beach with potential for increased**

	habitat for colonization but could also result in burial of individuals and seedbank.
Seabeach knotweed (*Polygonum glaucum*)	Minor to Moderate negative or positive effect. Beach nourishment could result in mortality to plants or burial of seed bank if conducted outside of safety window or protocol. FWS guidelines will be followed to avoid, minimize and compensate, including surveying, fencing and monitoring. Nourishment could result in a wider beach with potential for increased habitat for colonization but could also result in burial of individuals and seedbank.
Least tern (*Sterna antillarum*)	Negligible to Minor negative or positive effect. Beach nourishment would result in a wider beach with more foraging and nesting habitat. Since birds are not in area during construction time, no direct adverse impacts anticipated. Surveys, monitoring and FWS protocol will be followed. Potential indirect negative effects: preclusion of natural and overwash habitat, creation of sink/sub-optimal habitat, manipulation of prey base, increased recreational and predation impacts. Potential to adversely affect, but species not expected to be present during project period.
Northeastern Beach Tiger Beetle (*Cicindella dorsalis dorsalis*)	Not likely to adversely affect because this species has not been detected at Gunnison Beach or the Critical Zone, but continued surveys will provide for detection of larvae and adults. Renourishment will maintain existing shoreline conditions at occupied northern beaches.
Finback whale (*Balaenoptera physalus*)	Not likely to adversely effect. Species has not been documented in action area during proposed project activity period. NMFS conservation measures will be followed and safety windows will avoid and minimize impacts.
Humpback whale (*Megaptera novaeangliae*)	Not likely to adversely effect. Species has not been documented in action area during proposed project activity period. NMFS conservation measures will be followed and safety windows will avoid and minimize impacts.
Right whale (*Balaena glacialis*)	Not likely to adversely effect. Species has not been documented in action area during proposed project activity period. NMFS conservation measures will be followed and safety windows will avoid and minimize impacts.
Green sea turtle (*Chelonia mydas*)	Potential to but not likely to adversely effect. Species has not been documented in action area during proposed project activity period. NMFS conservation measures will be followed to avoid and minimize impacts. Safety windows and borrow activities being restricted to surf zone will avoid and minimize impacts. Potential for indirect habitat impacts.
Loggerhead sea turtle (*Caretta caretta*)	Potential to but not likely to adversely effect. Species has not been documented in action area during proposed project activity period. NMFS conservation measures will be followed to avoid and minimize impacts. Safety windows and borrow activities being restricted to surf zone will avoid and minimize impacts. Potential for indirect habitat impacts.
Kemp's ridley sea turtle (*Lepidochelys kempii*)	Potential to but not likely to adversely effect. Species has not been documented in action area during proposed project activity period. NMFS conservation measures will be followed to avoid and minimize impacts. Safety windows and borrow activities being restricted to surf zone will avoid and minimize impacts. Potential for indirect habitat impacts.
Leatherback sea turtle (*Dermochelys coriacea*)	Potential to but not likely to adversely effect. Species has not been documented in action area during proposed project activity period. NMFS conservation measures will be followed to avoid and minimize impacts. Safety windows and borrow activities being restricted to surf zone will avoid and minimize impacts. Potential for indirect habitat impacts.
Hawksbill sea turtle (*Eretmochelys imbricate*)	Potential to but not likely to adversely effect. Species has not been documented in action area during proposed project activity period. NMFS conservation measures will be followed to avoid and minimize impacts. Safety windows and borrow activities being restricted to surf zone will avoid and minimize impacts. Potential for indirect habitat impacts.

Mitigation Measures to Minimize Impacts

Mitigation Measures

The following mitigation measures and development constraints are specific actions that when implemented, would minimize, avoid, or eliminate impacts on resources that would be affected by the alternative actions. The National Park Service would fully comply with all applicable laws, regulations, and policies governing resource protection including the Endangered Species Act, Clean Water Act, Clean Air Act, National Historic Preservation Act, and agency specific guidelines. These resource protection strategies would be implemented under the action alternative to provide an effective monitoring and management program.

Natural Resources

Piping Plover

- ♦ Sand removal and fill will occur outside the sensitive seasons for the T & E species (March- September) to avoid disturbing these species and their habitat. The project is scheduled to begin after October 1 and be completed by March 1. This schedule is outside of the breeding season and will avoid direct impacts and minimize indirect impacts to this species.
- ♦ An intensive plover monitoring program will be implemented. All potential activities that may harm or harass breeding piping plovers will also be recorded, abated and monitored. Corrective action will be immediately taken and adaptive management to prevent further occurrences will be incorporated into the management scheme by NPS biological personnel at Sandy Hook and Gateway's Division of Natural Resources. Adequate staffing and trained personnel will monitor, prevent and enforce human and other disturbances at each of the nesting sites during critical nesting stages as stated in the FWS consultation letter of 5/21/92 and the Plover Management Plan.
- ♦ Off-road-vehicles will be prohibited year round, and dogs will be prohibited on ocean beaches from March to September to protect piping plovers.
- ♦ An intensive predator monitoring and management program will be implemented in order to determine any effect of the project on predator populations or their impacts on plovers.
- ♦ Vegetation and other beach characteristics deemed important to plovers will be monitored and managed to maintain optimum nesting and foraging conditions
- ♦ If piping plovers nest on beach fill material all protection measures will be implemented to protect nesting areas from predators and public use, including closing the beach for a distance of 100 meters from any nest site. Protection measures and monitoring efforts are those outlined in the FWS recovery plan for Piping Plover (FWS 1996b) and 1992 consultation letter and the Sandy Hook Unit Piping Plover Management Plan (NPS 1992). Nests in the Critical Zone will continue to be

protected with signs, ropes, and intertidal closures during the critical nesting stages. Snow fencing will be placed around the road access areas where plover chicks might attempt to cross the road to forage in the back bay flat habitats. Intensive monitoring of nests and chicks will be conducted through fledging, and trained personnel will be stationed at the ends of the protected zones for enforcement and education purposes. Due to the proximity of the Critical Zone fill area and Gunnison beach borrow area to recreational bathing beaches, additional protection staff will be assigned as necessary to enforce shorebird area closures.

- Only the intertidal zone and nearshore bar portion of Gunnison bathing beach (that approx. 1500 ft area between the restricted protection areas) that is accreting on an annual basis would be removed so as not to result in a net loss of habitat. The elevation of the beach berm around potential nest site locations would be maintained, and sand would only be removed from the nearshore bars and intertidal zone to minimize the potential for habitat disturbance and nest flooding. Only that amount of sand accreting each year will be removed as a slurry at or below the water line. Similarly, the fill area at the Critical Zone will be seaward of any potential beach use in the breeding season, and fill will be placed along the intertidal zone and beach face so as to minimize impact to the beach profile and integrity.

- Nesting status and reproductive success would be monitored throughout the nesting season along all Park beaches, including both Gunnison and the Critical Zone to ensure that the project was not having an adverse affect on nesting plovers. Surveys will include data collected from qualified, trained biologists. Field data will be available for FWS inspection daily and record the # eggs when nest found, status of nest, eggs, chicks, and adults, as well as exact cause of nest loss or mortality. This monitoring protocol will provide for quick response to and disturbance factors.

- Several transects located at the Critical Zone, Gunnison Beach, North and Coast Guard Beaches will be established and surveyed and beach characteristics recorded, including vegetation, profile, substrate, etc. in order to determine changes related to the project.

- Outreach and educational efforts will be increased on Sandy Hook regarding piping plovers to increase compliance with measures to reduce take due to recreational and ORV use.

Seabeach Amaranth

The scheduled time period for the project (October 1 – March 1) is mostly outside the growing season, which has recently been determined to extend into December for seabeach amaranth.

- Since seabeach amaranth is an annual, most plants existing in the Critical Zone area on the August/September survey will reach mortality by the project start date.

- Most of the plants discovered during the Critical Zone survey are located high on the beach and are outside of the fill template. The location of these plants will be marked and protected with string lines to prevent any disturbance of the immediate area by construction personnel or vehicles involved in the fill project.

- To insure the seeds produced by these plants are not covered and lost by the fill project, seeds, if present, will be harvested and stored. The collected seeds will be distributed the following season in the same location on the beach. Established plants will be transplanted to the renourished portion of the beach.

- FWS (2003) recommends that NPS raise the public's awareness of the status, life history, and threats to seabeach amaranth and facilitate its protection.

- Monitoring data will be supplied annually to agencies engaged in protecting and restoring the species to enhance interagency data sharing.

- When implementation of the proposed transplanting strategy is anticipated, activities to be conducted under this strategy will be coordinated with FWS and other agencies/organizations prior to implementation.

- Surveys will be conducted involving the collection of data on plant size and reproductive stage, GPS coordinates or location relative to permanent landmarks, the plants' location on the beach profile (position relative to the dune tow or apparent high water line), plant associates, a description of the occurrence (dispersed or concentrated), evidence and extent of predation, and documentation of any other threats, should be conducted.

- Populations will be monitored for evidence of herbivory, both insect and mammalian, herbivores will be identified if possible, and the results will be reported to FWS.

- A program of long-term storage of amaranth seeds collected from various parts of Sandy Hook will be implemented as insurance against catastrophic population declines.

Least tern

- The same conservation measures used for piping plover will be employed for any least tern nests or colonies located on the new fill including public use closures through symbolic fencing.

Seabeach Knotweed

- The seabeach knotweed plants located in the Critical Zone were found high on the beach and are not within the proposed fill template. The location of these plants will be marked and protected with string lines to prevent any disturbance of the immediate area by construction personnel or vehicles involved in the fill project. Since they occur in the same area as amaranth, these species will be protected simultaneously.

Northeastern Beach Tiger Beetles

- No tiger beetles have been located in the borrow or fill areas, but continued surveys will provide for detection of larvae and adults. Beetles had been reintroduced onto North beach at the northern portion of Sandy Hook as part of the Atlantic Coast recovery effort but none have been recorded near either the borrow or fill areas. Protection measures will be implemented for any individuals located in either site. NPS will consult FWS staff if additional locations are found and will follow the specific guidance from the FWS consultation letter of 9/23/94.

Sea Turtles and Marine Mammals

- A database mapping system to create a history of use of the geographic areas affected and endangered/threatened species presence/interactions on which to base future management decisions will be maintained.

Coastal Geomorphology

- A detailed topographic survey of the Critical Zone beach will be performed prior to pumping to collect data on beach morphology and calculate the volume pumped. These data would provide a baseline against which to measure future changes. A digital terrain model will be developed to portray profiles and spatial association of slopes and forms.

- Surveys will continue to be conducted on a monthly basis to establish rates of shoreline change and sediment accumulation or transfer. Progress reports based on survey results will identify the sequence of changes to the topography and the volumes of sand involved. This information will be provided to regulatory agencies including the FWS and New Jersey Department of Environmental Protection to ensure that the project is not having an adverse effect on rare beach flora and fauna or coastal geomorphology.

- Annual surveys of the full ocean shoreline of Sandy Hook will be conducted via a vehicle-mounted GPS receiver and entered into the digital atlas of shorelines to continue to assess conditions of sand transport and beach response all along the spit.

Gunnison Beach Borrow Area:

A monitoring program will be established to ensure that sand is not removed from Gunnison Beach faster than it can accrete on an annual basis. The program will involve topographic surveys of the beach to determine the net removal of sand as well as the rate of accumulation and its spatial pattern during recovery. Specific actions to be performed as part of the monitoring program include:

- A detailed topographic survey of Gunnison Beach performed prior to initial pumping, to collect data on beach morphology and sand volume. These data would provide a baseline against which to measure future changes. A digital terrain model would be developed to portray profiles and spatial association of slopes and forms.

- Sediment samples collected from all habitats that occur along the beach profile.

- Survey and sediment sampling extending 300 feet updrift and downdrift of the borrow area to determine the extent of effects beyond the borrow zone boundaries.

- Monitoring data describing the position, number, and sequential movement of the spit extensions that are characteristic of sediment transport at this location.

- Surveys conducted on a monthly basis to establish rates of shoreline change and sediment accumulation. During pipeline operation, surveys would be performed bi-weekly or at an interval appropriate to the degree of change occurring. Surveys would be repeated at monthly intervals after pumping ceases.

- Progress reports based on survey results to identify the sequence of changes to the topography, the sediment grain sizes, and the volume of sand involved. This information would be provided to regulatory agencies including the FWS and New Jersey Department of Environmental Protection to ensure that the project is not having an adverse effect on rare species or coastal geomorphology.

- Survey data collected from Gunnison Beach would be compared with data from similar surveys performed at the Critical Zone to help balance sediment budgets.

- Quarterly surveys of the full ocean shoreline of Sandy Hook, conducted via a vehicle-mounted GPS receiver and entered into the digital atlas of shorelines to continue to assess conditions of sand transport and beach response all along the spit. This would provide confirmation that sand removal from Gunnison Beach is not disturbing beaches downdrift

- Monitoring of North and Coast Guard Beaches, conducted on a much less intensive basis, but added to this monitoring protocol and focusing on detecting any potential beach changes due to the replenishment project. These accreting beaches have shown a net annual accretion and support most of the T & E species habitat. Therefore, NPS will begin coarse monitoring of these important sites by establishing transects along each beach, as well as continuing the intensive monitoring along Gunnison and the Critical Zone. Vegetation and T & E species monitoring will be coordinated with these activities so that changes or impacts can be appropriately detected. Morphological shoreline and biological monitoring timing and protocol will be coordinated in order to provide the most effective data for management.

- This monitoring protocol will measure and determine any systematic loss of sand volume and inland displacement vs. normal variation. Systematic loss indicating pipeline impacts of accretion rates and shoreline profile will trigger consultation with FWS in order to determine no impact on Gunnison accretion and long-term capture of pass- through sand.

- All project personnel and contractors are fully informed of and compliant with all conservation measures, reasonable and prudent measures, and terms and conditions of this and any ensuing Biological Opinion and consultation documents. Project personnel and contractors will be provided a written summary of the above documents and will participate in a pre-construction meeting to review each item.

- Project personnel and contractors, and the FWS will be informed of the location of any species or habitats of concern, should they be encountered during the project operation. Annual survey results will be provided.

- Additional public and project personnel outreach will be developed in attempts to improve awareness and compliance for rare species conservation at Sandy Hook.

- Staffing in order to fulfill pipeline project monitoring requirements at the fill and borrow sites will not detract from existing monitoring of other sites.

Vegetation and Ground Disturbance:

To minimize unnecessary ground disturbance and vegetation impacts resulting from construction, equipment and materials would be stockpiled on previously disturbed sites or within beach construction footprints. Construction limits would be identified in construction documents and specifications, and fenced or signed in the field to further protect native vegetation and environmentally sensitive areas from disturbance. A construction supervisor would monitor ground and vegetation disturbance to ensure that it is restricted to the minimum area necessary. All project personnel and contractors will be informed of and compliant with all conservation measures, reasonable and prudent measures, and terms and conditions of this and any ensuing Biological Opinion and consultation documents.

- Vegetated areas impacted by construction would be restored to natural conditions, wherever possible. Natural succession and regeneration by native species will be allowed to occur naturally, unless there is a need to hasten that process for erosion control or other purposes. In this case, native beach grasses would be used to stabilize dune areas; vegetation matching that which existed in an area prior to disturbance would be utilized elsewhere. Aesthetically undesirable areas would be screened by native plantings where necessary. In areas where fast green-up was desirable, mature native plantings would be used, however, minimal ground and vegetation disturbance is expected.

Site Excavation and Grading:

- To minimize unnecessary ground disturbance and vegetation impacts resulting from construction, equipment and materials would be stockpiled on previously disturbed sites or within construction footprints. Construction limits would be identified in construction documents and specifications, and fenced or signed in the field to further protect native vegetation and environmentally sensitive areas from disturbance. A construction supervisor would monitor ground and vegetation disturbance to ensure that it is restricted to the minimum area necessary.
- The pipeline and related appurtenances would be designed to minimize cuts and fills as well as removal of existing native vegetation. Required fills would be sloped to provide positive drainage without erosive effects. Control measures would be implemented to keep effects such as sediment or erosion within construction limits.
- Actions would be taken to ensure that runoff and sediments from the project area do not enter creeks, streams, or other bodies of water. Runoff would be controlled in compliance with federal and state regulations.
- Barricades would be installed at the outset of the project and used where necessary to prohibit unauthorized access to sensitive areas.

Pipeline/pump Operation Personnel Requirements:

- Pre-construction and weekly meetings covering natural resource issues and protection measures would be conducted as determined by the Park Superintendent.

- Personnel tasked with the operations and maintenance of the pipeline/pump would be required to attend natural resource-related training sessions conducted by Park staff to raise awareness of the reasons why the Park was established and how effects on the natural environment can be minimized during construction.
- The operation protocol documents would clearly indicate which work activities could occur only when an appropriate resource staff is present to monitor such activities.
- Damage costs would be established in any potential contract or tasks order that would discourage any pump/pipeline personnel from causing adverse effects in adjacent areas.
- Work documents would indicate areas where hand work is required to minimize disturbance around existing utilities, mature vegetation, or other sensitive areas.
- An incentive clause would be established to encourage the pump/pipeline personnel to disturb even less area than that shown on the construction documents.
- Any animals that might enter construction areas would be protected from harm by the pump/pipeline personnel and the NPS project supervisor. The Park staff would be notified of any animals found in construction areas and would be allowed to relocate animals as necessary.

Cumulative Impacts

Sandy Hook is surrounded by artificially stabilized shoreline and beach replenishment along both the NJ and NY coast. The FWS has conducted informal Section 7 consultations with the ACOE on the numerous projects ongoing in the NY-NJ recovery area. The following list of projects is not meant to be all inclusive; however, it highlights the recent history of and reliance upon beach stabilization of this area.

<u>Other related shoreline stabilization and replenishment projects within the NY -NJ recovery Unit</u>

Shinnecock Inlet Reformation Project (December 8, 1986);

Fire Island Inlet and Shore Westerly to Jones Inlet Combined Navigation and Beach Erosion Control Project (May 1987);

30-year Westhampton Interim Storm Damage Protection Project (December 1994);

3-year Breach Contingency Plan (BCP) (July 1995);

Fire Island Inlet and Shore Westerly to Jones Inlet Combined Navigation and Beach Erosion Control Project, Seabeach Amaranth Transplantation Program (May 1995);

15-year Shelter Island, New York, Erosion Control Project (June 1995; revised October 1997); and

6-year West of Shinnecock Interim Storm Damage Protection Project (Draft Biological Opinion August 1999; final Biological Opinion pending).

Additional informal section 7 consultations for numerous other NY projects include:

Long Beach Island Beach Erosion Control (May 1994);

Moriches Inlet Navigation Project (March 1996 and July 1998);

Jones Inlet Jetty Rehabilitation Project (June 1995 and July 1998);

Shinnecock Inlet Navigation Inlet Maintenance Dredging (July 1998);

Fire Island Inlet and Shore Westerly to Jones Inlet Combined Navigation and Beach Erosion Control Project (June 1999);

Coney Island; and

East Rockaway Shore Protection Project.

Of approximately 200 km (125 miles) of Atlantic coastline in New Jersey, stretching from Sandy Hook to Cape May, all but approximately 21 km (13 miles) (Sandy Hook Unit, Gateway National Recreation Area and Little Beach Island within the Edwin B. Forsythe National Wildlife Refuge) are encompassed within a Corps beach nourishment project area. Shore protection projects within the New Jersey portion of the New York-New Jersey Recovery Unit for which the Service completed informal section 7 consultation with the Corps for the initial phase of beach nourishment include the following:

Sea Bright to North Asbury;

Asbury Park to Manasquan Inlet;

Manasquan Inlet to Barnegat Inlet;

Barnegat Inlet to Little Egg Inlet;

Brigantine Inlet to Great Egg Harbor Inlet;

Great Egg Harbor and Peck Beach (Ocean City Beachfill);

Great Egg Harbor Inlet to Townsends Inlet;

Townsends Inlet to Cape May Inlet;

Cape May Inlet to Lower Township (Cape May Beachfill);

Lower Cape May Meadows to Cape May Point; and

Delaware Bay Coastline.

Authorized Corps navigation projects located within the New Jersey portion of the New York-New Jersey Recovery Unit include:

Shark River Inlet;

Manasquan Inlet;

Barnegat Inlet; and

Cape May and Ocean City.

Consultations on the adjacent renourishment activities at Sea Bright and Monmouth Beach in Monmouth County and Avalon and Stone Harbor in Cape May County, New Jersey have been ongoing and additional work is anticipated in the future at:

Lower Cape May Meadows and Cape May point (Fall 2002);

Brigantine (2003);

Southern Ocean City and Sea Isle City (2004);

Long Beach Island (2004);

Manasquan Inlet to Barnegat Inlet (2005); and

Great Egg Harbor Inlet to Townsends Inlet (2005).

Sandy Hook remains one of the least stabilized shorelines in the area; however, it has a century's history of stabilization. A major influence to the area's shoreline is now the ongoing ACOE long-term 50-year stabilization program for NJ coast. Effects of these projects have already been seen from the adjacent projects, including Sea Bright and Monmouth Co., NJ. The Sandy Hook Slurry Pipeline project seeks to stabilize a small section of beach with sand that would be passing through the system and lost to the Sandy Hook Channel. Although this project represents yet another replenishment project, its impacts are anticipated to be less than any of the larger projects listed above, and generally negligible because the unit is self contained and sand is being recycled and kept in this unit. The overall cumulative impacts of beach replenishment in NJ , however, are significant, and appear to have perpetuated the continuing need and cycle of stabilization on the NJ beaches. This is one more project which adds to the total impact.

Discussion

Each of the alternatives will affect Sandy Hook beaches and shoreline as well as the species that inhabit them. The No Action Alternative (A) appears to have the most unpredictable short and long-term impacts on natural resources due to the changeable nature of coastal dynamics and inlet/overwash formation. It could create additional overwash and back bay habitat with inlet formation, which would be advantageous to higher plover abundance and productivity. But the ephemeral nature of shoreline dynamics makes it difficult to predict the longevity and morphology of such newly created habitat. Additionally, though the creation of a new inlet could provide additional beaches suitable for plovers and other beach-dependent species, it is unclear whether the total shoreline of Sandy Hook would gain or lose suitable habitat due to the changes in sand transport caused by the new inlet. Serious consideration should be given to the existing, occupied, prime northern nesting beach habitat may be affected by altered sand transport conditions along Sandy Hook as a result. A breach clearly would have significant adverse impacts on both cultural and human resources, due to the potential loss of these historic structures as well as access to them. Human visitation would be reduced unless NPS could maintain access through another method.

In general, Alternative B's 2 options represent similar approaches to erosion control with the least amount of short and long term biological, cultural, and human resource impacts. It still represents a habitat manipulation project, but appears to be the least disruptive to the beach habitat and human resources, most predictable and practical, and should result in a responsible and effective resource protection program.

The implementation of this long-term proposed beach restoration project is intended to recapture sediment that is passing through the system (that would be lost to the channel due to the Monmouth Co beach fill perturbation) and recycle it back to the erosive southern end in the least intrusive way, maintaining the barrier spit. It is one of the numerous NJ shoreline stabilization projects, therefore contributing to the overall loss of natural coastal habitat. However, this project is in response to the adjacent pre-existing man induced changes which threaten Park Resources and Mission, and attempts to simulate the most natural shoreline processes possible through this sand recycling method.

Continual replenishment of the beach by recycling smaller quantities of sand on a regular basis through a sand slurry pipeline operation would more closely mimic natural shoreline dynamics while increasing and stabilizing the beach habitat necessary to sustain the area's rare flora and fauna. The potential natural resource loss associated with this alternative is the prevention of overwash and back bay habitat formation which may at some point benefit or limit piping plover nesting populations on Sandy Hook.

The preferred Alternative B, Option 2, with the use of the eductor, provides an additional environmental buffer over Option 1 to minimize water quality and marine life impacts. Option 2, therefore, provides the NPS with the most long-term, environmentally sound, cost-effective and flexible operation and maintenance system for beach replenishment.

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